AMERICAN JOURNAL
OF
PHYSICAL ANTHROPOLOGY

EDITED BY

ALEŠ HRDLIČKA

VOLUME VII

WASHINGTON, D. C.
1924

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American Journal of Physical
Anthropology

VOLUME VII JANUARY–MARCH, 1924 NUMBER 1

EVOLUTION OF THE HUMAN FOOT

II*

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*Part I in this Journal, 1922, V, No. 4, 305-336.

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INTRODUCTION

Section I has dealt chiefly with the structural differences which have been regarded by some authors as indicating the impossibility of deriving a human terrestial type of foot from one of gorilloid form. The conclusions presented in Part I apparently show that those structural differences are not such as to debar the possibility of this transformation but, on the contrary, the range of variation in foot structure within the modern species of gorilla displays modifications (because of the adoption of ground habits) which to a remarkable degree approach the human characteristics, as distinguished from the typically arboreal foot of the chimpanzee.

Special attention was devoted to Dr. G. S. Miller's criticism[1] of Dr. Gergory's views[2] concerning the derivation of the human foot. This led to an exchange of letters between Dr. Miller and the writer which has been of inestimable value in the subsequent study. The writer desires to state his appreciation of Dr. Miller's helpful and esteemed interest in these studies and to acknowledge the invaluable cooperation of Dr. Gregory, who also placed at his disposal the recent and fossil primate skeletons at the American Museum of Natural History. Mr.

[1] AMER. J. PHYS. ANTHROP. 1920. III. No. 2.
[2] *Bull. Amer. Mus. Nat. Hist.* 1916, XXXV, 332-336.

Carl E. Akeley of the same Museum very kindly loaned gorilla feet recently secured by him in the Belgian Congo. The use of material at Yale University through the courtesy of both Professor R. S. Lull and Professor H. B. Ferris has also been of very great assistance and value in pursuing this study.

The present paper takes up a consideration of the major points of variation in primate feet with the intent of determining the characteristics of the primitive human or prehuman foot. This will be attempted by holding to a consideration of only the primary factors of variation and the grosser differences, leaving for a later time a discussion of minor elements of variation and secondary developments.

FACTORS IN THE DIFFERENTIATION OF PRIMATE FEET

Primate feet show distinctive modifications which are associated with peculiar habitual usages. These modifications affect the various units and segments of the foot according to the movements of forces within the foot structure; the strength and direction of those forces are determined by the manner in which the foot is employed.

The number of bony units which enter into the framework of the primate foot are identical in all instances, except for an occasional loss of a phalanx through disuse.

The principal factors, conditions and causes of variation in form of primate feet are of three classes:

I. Inherited Form and Habits.
  A. Functional Divisions of the Foot.
  B. Chief Points of Variation.
II. The Mechanical Phenomena Directly Affecting the Foot Structure.
  A. Nature of Grasp.
  B. Position of Fulcrum.
  C. Size of Animal.
  D. Mode of Locomotion and Posture.
III. Changes in Habits.

I. Inherited Form and Habits

This implies the range of form and habits of any species or genus as ordained by inherited structure, inherited environment and inherited needs. All the members of such a group are characterized by similar habits and foot structure except for minor individual variations.

A most important element in this factor involves the habitat, whether the group is arboreal or terrestrial or whether they live both in the trees and on the ground. It is readily seen how arboreal usage will present very different mechanical movements of force through the foot as compared with terrestrial usage. The respective development would naturally be in divergent directions. Feet which are employed in both spheres will just as naturally show a combination of both types of development. For example, arboreal life is associated with the development of long digits and, except in one distinctive group, with a lengthening of the metatarsals. Terrestrial life effects short digits and long metatarsals. Where both uses are combined the digits are long, but the metatarsals prportionately longer than in the arboreal types.

A. FUNCTIONAL DIVISIONS OF THE FOOT

No attempt will be made in this paper to compare the individual bones and their variations in structure other that what is of necessity drawn into the discussion. If one figuratively makes use of a high-power glass to examine the subject he is immediately lost in a maze of minor differences which become magnified in importance; he loses all recognition of the few great and important differences or, if not, is unable to examine them comprehensively, or to obtain a proper sense of their proportion because of the very narrowness of his field of vision. The use of a low-power lens is necessary for the establishment of the correct relationship and proportion of the various parts; afterward the smaller details may be studied more effectively.

The foot therefore should first be analyzed as a mechanically functioning organ whose work is accomplished by the coordinate action of its major composite parts: the grasping digits, the opposing hallux, and the anterior and posterior leverage areas. Each of these major divisions has a distinctive part to perform in the complete function of the foot. A change in the mode of function of the foot inevitably means an alteration in the amount and manner of work demanded of one or more of these segments.

In other words, let the bone structure be regarded as a system of pipes or tubes by which force is transmitted as a liquid. A change in function, then, varies the activity of different muscles with the result that the various "streams" of force are altered both in direction and their proportionate intensity. Such a modified distribution of forces in the foot structure will lead to remodelling of the original form. Individual segments will show separately the more conspicuous changes because the proportionate functional alteration is greater in them than in the foot as a whole.

When primate feet are studied in this manner, any differences of structure associated with differences of habits, can be analyzed more easily and comprehensivly. The general structure of each functioning segment and the variation of individual bones will disclose a definite reason because they are susceptible to change according to the manner in which they are used.

The characteristic use of a primate foot is revealed by contemplation first of the major segments; afterward a proper valuation can be put upon the nature and degree of the modification of their smaller units.

Such a method of study furnishes a basis for a systematic and synthetic arrangement of variations in individual foot bones, whereby the physical structure of certain single bones can be made to disclose the relative importance and character of the function of their segment. In turn, the segment may afford information bearing upon the nature of function and structure of other segments; in this manner the characters and mode of use of the foot may be determined with a considerable degree of accuracy, and also the important habits of the animal.

As an example, a primate first metatarsal bone with a long peroneal tubercle may be considered. To the usual student of anatomy it would be recognized merely as a first metatarsal bone with an unusually developed tubercle. If, however, it is studied in the manner described above, the long tubercle would not only indicate wide abductability but also that the hallux was an important functionating structure. These points would indicate a clinging or perching type of grasp and consequently give some intimation of the nature of the other segments. If to this bone is added one or two distinctive bones from other segments of the foot, it would be quite possible to be assured of the exact function and character of the foot, in the light of knowledge of the effects various modes of function exert upon the primate foot structure.

Thus, while certain developments and their probable causes are obvious, the correct interpretation of the numerous smaller differences in individual bones can only be obtained after a proper understanding of the correlation of the essential phases of function of the larger segments has been worked out and applied.

The primate foot may be divided into five segments: four longitudinal sections and the hallucial member.

1. Posterior tarsal segment: from the posterior aspect of the os calcis to the mid-longitudinal point of the trochlear surface of the astragalus. This represents the posterior arm of leverage action.

2. Anterior tarsal segment: from the above point on the astragalus to a transverse line midway between the anterior facets of the middle

and outer cuneiform bones. This segment represents either the anterior leverage arm of the tarsi-fulcrumating* feet or the posterior portion of this arm in the metatarsi-fulcrumating feet.

3. Metatarsal segment: from the above described cuneiform line to the anterior end of the most distally placed metatarsal head. This is the anterior half of the leverage arm in "metatarsi-fulcrumating" feet.

4. Digital segment: from the metatarsal extremity noted, to a transverse line determined by the most distal phalangeal tip.

5. Hallucial member: the combined phalanges and metatarsal of the hallux.

B. CHIEF POINTS OF VARIATION IN THE FOOT SEGMENTS.

The principal differences within these segments which bear upon this analysis are as follows:

Digital segment. (1) Apparent lengthening or shortening of the phalanges. (2) Greater lengthening of the fourth and fifth digits over the second and third. (3) Apparent under-development of the second digit.

Metatarsal segment. (1) Apparent lengthening or shortening of the digital metatarsals. (2) Torsion of the metatarsals. (3) Variation in development of the second metatarsal.

Anterior tarsal segment. (1) The anteroposterior lengthening or shortening of the mid-tarsal bones and of the anterior process of the os calcis. (2) Variation in the entocuneiform—metatarsal facet. (3) Variation in the scapho-cuneiform fossa. (4) Lateral compression of the mesocuneiform.

Posterior tarsal segment. Variation in the length and stoutness of the posterior process of the os calcis, and in the slant of the calcaneal facets.

Hallucial member. (1) Variation in the length of this combined portion. (2) Its abductability and adductability. (3) The torsion of its metatarsal shaft. (4) Length of its peroneal tubercle.

II. The Mechanical Phenomena directly affecting the Foot Structure

A. NATURE OF GRASP.

The difference between opposability of the thumb in the human hand and the grasping action of the primate hallux has been shown in Part I. There the difference between the human and the anthropoid ape feet were analyzed, but in this paper, where various members of the primate order are under consideration, other modifications are to be recognized.

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*("Tarsi-fulcrumating" refers to the use of the anterior end of the tarsus as a fulcrum for the leverage action of the foot, while "metatarsi-fulcrumating" indicates the use of the heads of the metatarsals for that purpose.)

The hallucial grasp is characterized by adduction of the first metatarsal combined with a converging flexion of hallux and digits. This converging flexion is conditioned by a torsion of the metatarsal shafts so that the plantar surfaces of the hallux and the digits are brought into separate planes lying approximately at a right angle to each other. The action of flexion brings the hallux and digits into contact. This method of grasping prevails generally in primate feet. Torsion of the hallucial metatarsal gives the appearance of a remodelling of that bone so that the extensor-flexor plane of the hallux coincides with the pull of the long peroneal muscle. Torsion of the digital metatarsals varies in different feet from a mild degree to over 45°, and is always most marked in the second. A well developed hallux and marked torsion of the digital metatarsals are constant elements in the balancing grasp of the great ape group. The peroneal tubercle is well developed in arboreal feet but not conspicuously elongated with this type of grasp.

The clinging or perching grasp is particularly notable among the smaller lemuroid forms and in *Tarsius*. It is characterized by a disproportionate lengthening of the fourth and fifth digits and a remarkable development of the hallucial member.

Its mechanics are more easily understood by a little personal experiment. If one grips a two-inch rod, he gets his best hold by counterpressure of the thumb upon the area opposite the middle digit. But if this be tried on a thick six or seven-inch pipe or beam, the grip will be found to be more effective between the hallux and the outer digits because the width of the palm helps to cover the increased span.

The smaller primates present this mode of grasp most conspicuously. They are essentially arboreal in habits and the girth of most of the branches among which they live, is large compared with the span of their feet. The perching type is a more highly developed form of the clinging grasp.

Other associated features besides the two mentioned are, comparative underdevelopment of the second digit, extremely wide abductability of the hallux with a long peroneal tubercle on the first metatarsal, a vertically concave entocuneiform facet, short metatarsals (digital) and only slight metatarsal torsion, if any. The absence of torsion is logically explained by the fact that in very wide abduction flexion of the hallux moves almost directly toward the digits, especially the outer ones, in a transverse plane perpendicular to the sole of the foot.

Among the larger lemurs lengthening of the metatarsals and increased torsion seems to indicate a change toward the more common method of hallucial grasping discussed above.

The Suspension Grasp. This type of grasp is performed by the digits only; the hallux is not brought into play. In the other methods the foot is positioned directly above the surface of the supporting branch, but in this one, as the term implies, the body weight is suspended by a hooked position of the digits with the foot pendent to one side of the supporting surface. It is comparable with the position of a man's hands when he hangs from a horizontal bar.

This method is very generally employed in the manus of primates, as it permits quicker release for active arboreal movements than a grasp which brings the thumb into use. In fact, so universally is this hold used in the manus that throughout the primate order, excepting man, the pollex represents various stages of reduction to practically complete obliteration, and opposability is likewise reduced or lost. The suspension grasp is not habitually used by the feet of primates except in orang and *Ateles*, two very highly specialized arboreal animals. The foot characters which both of these primates show, are, digital metatarsals with an absence of torsion of their shafts but extremely long and plantarly curved, particularly so in the orang; short posterior process of the heel; the hallux, which is considerably reduced even to the loss of a phalanx, still retains a wide degree of torsion, and of abductability.

Other types of feet. There are three other types of feet that should be considered before leaving this subject.

The rodent-like foot of the small marmoset is unique among the primates. Its rudimentary hallux is incapable of any appreciable degree of independent movement. The foot has no ability to grasp other than by using the "suspension hold" on relatively horizontal surfaces. On vertical surfaces the bodyweight is suspended by its sharp digital claws instead of by grasping. The twist of the first metatarsal clearly shows the use of an earlier grasping function of the foot.

The ground-ape foot will be considered more fully under another heading. The grasping hallux is undoubtedly a heritage from arboreal ancestry, which in the change of habitat, has not been utilized or included in the essential act of the locomotion. It has consequently been reduced in size, but still retains much of its former grasping mobility and character.

The human foot has practically lost the power of grasping although it still retains all the soft structures which performed that action, as well as a curvature of the entocuneiform facet upon which the movement took place. This curvature, however, is now greatly flattened. The first and second metatarsals still show a mild degree of the earlier torsion. In contrast with the case of the ground apes (where the change to terrestrial habits decreased and, in fact, eliminated the use of the hallux in locomotion), in man a great share of the burden has been thrown upon that member. A remodelling of the former structure has been acquired, enabling the hallux to perform its new function in a most efficient manner. Although the human specialization has produced very marked changes, it has failed nevertheless to obscure all evidence of arboreal usage; in fact, some of the earlier arboreal characters are basic and essential elements in the ultimate development of the human foot.

In a general survey of primate feet the grasping function stands out as distinctive of arboreal habits. The types of grasp which have been described must not be considered as restricted to particular groups, for this is not the case. Any method may be used by almost any group or species, according to circumstances. What is implied is that certain primates habitually use a particular grasp and that the structure of the foot conforms with that usage.

B. POSITION OF THE FULCRUM

That this factor is of very great importance can easily be recognized by a glance at the *Tarsius* foot (Fig. III). Classified by the act of foot leverage, the primates present two distinct divisions, one in which the principal fulcrum is represented by the anterior end of the mid-tarsal bones, and another group which employs the distal ends of the metatarsals. The first division may be designated the "tarsi-fulcrumating group," the second, the "metatarsi-fulcrumating group."

Each of these groups contain representatives in which the characteristic type of leverage is carried to a high degree; for example, *Tarsius*, mentioned above, as a member of the first group, and the ground apes and man as specialized forms of the second. There is no distinct line of demarkation, however, for the flexibility of the arboreal or semi-arboreal primate foot permits a hyperextension of the metatarsals whereby leverage action may be begun on the tarsal part as a fulcrum and completed by the metatarsals. Terrestrial usage and cursorial locomotion are definitely associated with metatarsal fulcrumation and apparently promote its development.

1. *The tarsi-fulcrumating group* is practically limited to *Tarsius* and

the lemuroids.. In order to demonstrate more clearly the result of leverage action of this type, reference is made to the feet of the *Tarsius*, the *Galago* and the *Loris* (Figs. III, IV, V). All three of these primates show the same characteristics in the anterior segments; the hallux and the outer digits perform the tightly clasping action, while the digital metatarsals act passively as a span. Because of the tight grasp which stretches across the anterior part of the tarsals, and prevents any elevation of the basal ends of the metatarsals, leverage action must necessarily be accomplished posteriorly to this part. The result as seen in the *Galago* and in *Tarsius*, namely, an elongation of the scaphoid and of the anterior process of the os calcis, shows this development to a remarkable degree when constrasted with the almost undisturbed contour of this part in the slowly moving Loris, which undoubtedly preserves the original pattern in this part. To a mild extent this elongation prevails throughout the Lemuridæ and also appears among others of the small arboreal primates. It is recognized by the advance of the calcaneocuboid joint beyond the astragalo-scaphoid joint.

2. *The Metatarsi-fulcrumating group* includes all the other primates both arboreal and terrestrial. Such a broad classification is made because the tight clutching grasp which characterizes the tarsi-fulcrumating group is loosened, and the metatarsal bones are thereby permitted to be used in the propulsive effort. Locomotion throughout this group is distinctly cursorial, whereas in the previous group it was of a leaping or a slowly moving type.

Effect upon the Metatarsal Segment. This variation in the mode of foot leverage acts especially upon the metatarsals, lengthening them in a manner commonly observed throughout the entire mammalian class. When the feet of animals that have acquired greater speed than their predecessors are examined, it will be noted that the resulting conspicuous lengthening takes place principally in the metatarsal area. This is true both in the forms where the heads of the metatarsals, as the fulcra, bear directly upon the ground, as in the carnivores, and also in the true unguligrade animals, in which only the tips of the distal phalanges touch the ground.

In the terrestrial apes the metatarsal segment is distinctly longer than the digital segment. The reverse of this fact holds true in the arboreal forms and to a lesser degree in those which are active both in the trees and on the ground. In both of the latter groups, digital length exceeds that of the metatarsal segment.

The primitive Line of Leverage. In the feet of terrestrial apes, the third metatarsal bone presents the most distally extended head. Such an arrangement clearly indicates that the line of leverage coincides with this bone. It is an arrangement that may be termed the "primitive" line of leverage for it has existed since earliest primate and pre-primate life, and is generally observed throughout mammalian forms. In all the smaller primate genera, both arboreal and semi-arboreal, this primitive line is constant, and suggests that in their cursorial movements in the trees a non-grasping posture of the foot is employed to a large extent upon the larger branches as on the ground. Such an interpretation was verified by observations by the writer of various primates at the New York Zoological Park. The grasp was chiefly used when the supporting bar or branch was of sufficiently small size to fit the span, or wherever the balance of the body was jeopardized by the unsteadiness of the supporting bar.

Variations in the mid-tarsal Area. In contrast to the metatarsal lengthening, bones which lie between the metatarsals and the ankle joint show little change in that direction. In fact, where the animal has assumed greater bulk of body the mid-tarsal bones become definitely compacted and shortened antero-posteriorly, in spite of the marked lengthening that may have taken place in the metatarsals in association with more rapid locomotion.

The above phenomenon is beautifully shown in the evolutionary series of the horse. During the period of early increase of size in the small primitive four-toed animal, there is a distinct lengthening of the mid-tarsal bones conforming with a much greater growth of the metatarsals. But this continued only to a certain stage, for from then onward as the bulk of the animal increased, although the metatarsals continued to lengthen, the mid-tarsal bones became actually, as well as proportionately, shorter.

Another observation which bears upon this subject is that during the early period when the digital joints were undoubtedly more flexible, the increase in the growth of the phalanges seemed to be commensurate only with the actual increase in size of the animal. Later, however, when the true unguligrade posture of the foot was completely established, by the development of tougher and inelastic plantar ligaments and structures for the joints of the middle digit, then the process of lengthening due to leverage action appears to have been transferred from the hypertrophied middle metatarsal to the phalanges according to the degree in which they were rigidly held against hyperextension.

The attainment of greater size in a species of more slowly moving habits presents quite a different picture. In this case the increase in size, which is a gradual process, is accompanied by a proportionate sturdiness of bone without any great variation in the relative length of the segments. What variation may be noted is effected in the direction of obtaining more powerful leverage, as by a lengthening of the heel. It is in the attainment of greatly increased body bulk without a correspondingly greater sturdiness of foot bones, that the crushing effect is observed, and most conspicuously in herbivorous quadrupeds whose frames are slender in comparison with the bulk of the body.

Observations on Mammalian Feet. Examination of various mammalian feet shows:

(1) In a lengthening of the anterior arm of the lever for the purpose of more rapid motion, the elongation is greatest in the most anterior *rigidly-fixed* segment of the foot against hyper-extension;

(2) The digits, as freely flexible members, are not involved in the lengthening associated with leverage.

(3) An increase in size of an animal *without an increase in relative speed*, does not disturb the ratio of the lengths of the respective bones involved in the leverage act.

(4) An increase in the weight of body bulk which is disproportionate to the development of the foot in stoutness, is associated with an antero-posterior shortening or crushing of the mid-tarsal bones.

3. *Leverage Effort and Bowstring Action.* One other phenomenon should be considered before leaving the discussion of leverage. There are two sources of power in propelling the body weight: (a) the larger calf muscles (gastroc-nemius and soleus) directly attached to the heel and (b) the bowstring action of the hallucial and digital flexors, and also of the peroneal muscles.

In the grasping function of arboreal life the flexors are strongly developed. Their action, however, is clearly separated from that of the calf muscles, for during the act of propulsion, as in leaping from a *grasping foot-hold*, the flexors must be relaxed almost simultaneously with the period of propulsion. This synchronous relaxation of the flexors and contraction of calf muscles is necessary only when the flexors are employed in a grasp. In leaping from a non-grasping position of the foot, the flexors may act in conjunction with the calf muscles.

It is interesting to note, in this connection, the peculiar "spongy" resiliency of the gibbon's terrestrial gait. This animal is characteristically arboreal. Its method of locomotion in the trees, especially in forceful movements, is customarily by swinging leaps by means of the arms (brachiation), which supplants to a corresponding extent the propulsive effort of the legs. As a result, the calf muscles are not strongly developed, and the posterior process of the os calcis is very small, while an important development of the flexor muscles of the leg and foot is insured by the balancing grasp of the foot made necessary by its erect posture and bipedal locomotion in the trees. In terrestrial locomotion which has no call for the grasping function, this deficiency in the strength of the calf muscles is compensated by the bowstring activity of the flexors and peroneal muscles. The peculiar terrestrial gait of the gibbon is clearly due to the unusual ratio of propulsive action displayed by these two sets of muscles.

C. SIZE OF THE ANIMAL

It will be noted that in the feet of the anthropoid apes, the head of the second metatarsal bone is more distally located than that of the third. The same condition is to be found among the larger New World primates but is not constant in them as among the great apes. The presence of this condition in only the larger arboreal primates, and its absence in all the smaller forms as well as throughout the rest of the mammals, can be explained only by the combination of arboreal life and increase in size. The smaller primates, as before stated, use a terrestrial, cursorial mode of locomotion except when among the smaller branches. An increase in size is accompanied with a greater span of the foot and facilitates the development of a more secure grasping, balancing hold.

1. *The Humanoid Line of Leverage.* The results are more far-reaching, however, than the mere increase in the ability to grasp, for the more constant and habitual usage of this posture of the foot establishes a new, or "*humanoid*" line of leverage. This line runs along the inner border of the foot between the two grasping members, i. e. between the first and second metatarsal bones. Apparently the grasping posture of the foot is too intermittently and insufficiently used by the smaller primates to develop this line of leverage between the first and second metatarsals as a characteristic trait. The change was an essential one for the ultimate development of the human foot.

2. *Metatarsal Torsion.* With the adoption of the humanoid line of leverage, torsion of the metatarsal shafts is carried to its highest development. The following explanation of this torsion is obvious. When the line of leverage is changed to pass between the first and second metatarsals the fulcrum is no longer the heads of the metatarsal bones

but becomes the web between the hallux and the second metatarsal which spans the upper surface of the branch. Fig. I. The principal element of this web of soft tissue is the transverse adductor muscle of the hallux. This muscle is attached to the plantar surface of the first and of the second, third and fourth metatarsals near the heads of these bones. Downward pressure upon these bones tends to make them roll outward (from the intervening branch) and downward until the attachments of the supporting muscle present upon the upper and nearest surfaces. Such an actual movement of the metatarsal bones, however, is prevented by the firm attachments of their bases; consequently a torsion of the slender shafts results under the strain of the body weight. This twist, incidentally carries the digits into a more advantageous position for grasping. With the adoption of ground habits or the use of the suspension grasp, the need for this torsion is removed. Hence, in gorilla, man and orang, a marked reduction of this metatarsal twist is to be noted.

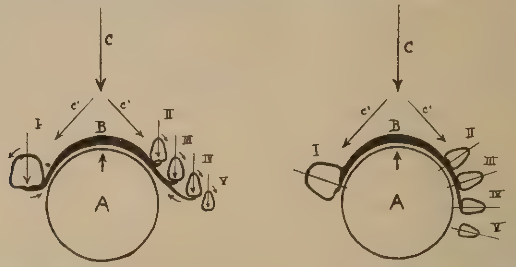

Fig. I. Mechanism of metatarsal torsion in arboreal feet. Vertical transverse section. A, supporting branch; B, transverse adductor muscle; C, body-weight; c'c', distributed weight; I, II, III, IV, V, heads of metatarsal bones.

Explanation. Counterpressure from A sustains the fleshy web between the hallux and second metatarsal. The transverse adductor muscle B by its plantar attachments near the heads of the metatarsal bones, causes an eccentric pull against the body-weight transmitted by these bones. The effect is to roll the bones outward and downward on each side of the branch. Since the metatarsal bases are firmly held, against such movement, the adaptive position of the heads indicated in Diag. 2, is effected in part by the torsion of the slender shaft, and by some movement in the mid-tarsal joints of the outer side of the foot.

3. *Effect Upon Habits.* In addition to the change in the line of weight carriage, increased size considerably alters the circumstances of the primates so affected. It correspondingly tends to debar them from the use of smaller lateral branches which constitute the arboreal avenues of movement and promotes, (1) the development of vertical movements near the trunks of the trees, and (2) brachiation. Both of these acts are essentially associated with the use of the erect attitude instead of the quadrupedal posture. The increased grasping ability

associated with the torsion of the metatarsals facilitates the use of the vertical posture by enabling the foot to act as a more efficient means of maintaining balance.

D. MODE OF LOCOMOTION AND POSTURE

Many of the phases coming under this heading have already received consideration, but they may well be collected for clearer conception, as this subject lends much of value and interest to the comparison of the various foot structures.

Locomotion as associated with posture may be divided into several quite distinctive types.

1. Leaping from a squatting attitude, as in the *Tarsius* and among the lemurs. The terrestrial gait is a series of jumps in an upright position.
2. The slow crawl of the Lorisinæ, in quadrupedal position.
3. A cursorial quadrupedal gait, using the primitive line of leverage, which characterizes the small, arboreal primates and ground apes.
4. A cursorial quadrupedal gait, using the humanoid line of leverage and associated either with a greater use of the erect attitude and brachiation (as in the anthropoid apes), or with a retention of quadrupedal gait with a long prehensile tail (as in some of the large New World monkeys).
5. Brachiation, which necessarily brings the spine into a vertical position and is associated with a lengthening of the upper extremities, as in the anthropoid apes.
6. Bipedal locomotion, with the legs extended upon the trunk and the bodyweight borne by the lower extremities, as in the gibbon and man.

The leaping method of locomotion is a distinct divergent specialization and associated with elements of the perching or clinging grasp. Greater efficiency in movement may be brought about by the lengthening either of the tarsus or of the legs: *Galago*, *Propithecus*.

The slow crawl presents the same type of clinging foot as above, with a definite shortening or shortness of the posterior part of the os calcis. The limbs are of approximately equal length, the legs being slightly longer: Loris, potto.

The cursorial, quadrupedal gait. The limbs are of about equal length and maintain the spinal column in a horizontal position. It is the type of locomotion most commonly employed among the lower primates: *Cebus*, *Macaque* and ground apes, etc.

The cursorial gait, employing the humanoid line of leverage, is distinctly an acquirement of the larger primates. In the tailless Old World forms it comprises a balancing grasp of the hind feet which, associated with frequent use of brachiation and climbing, promotes the use of the erect posture. In the New World monkeys, however, it means only increased grasping ability, for, since they have developed prehensile tails, suspension by the tail counteracts the effect of brachiation (in which they are also adept), and they move erectly, with head up, or in an inverted position, head down, with equal facility. Hence, they have remained typical quadrupeds.

Brachiation is used to some degree by almost all primates but it should be considered a characteristic mode of locomotion only when the species presents a distinct increase in length of arms over that of the legs. Brachiation may be of a simple type, such as moving from one location to another suspended by the arms or, as in the gibbon, it may constitute the ability to throw the body for long distances through the air. Brachiation has undoubtedly been one of the most important factors in establishing the habitual use of the erect attitude.

Bipedal locomotion is demonstrated to a perfected degree by mankind and the gibbon alone. In these two forms only are the hands and feet kept free from the ground, excepting some Lemuridæ with their leaping gait.

There is a remarkable difference, however, in the manner in which they use the foot. Man is completely plantigrade, while the gibbon does not allow the heel to rest upon the ground. Man stands a large part of the time and usually walks when he moves; he runs only when occasion requires. According to the writer's observations of three gibbons at the New York Zoological Park, their movements when on the ground were entirely a restless, quick-running gait and they squatted immediately upon coming to a halt. These are important observations when comparing the massive tarsus of man with the slight one of the gibbon.

Supination. The supinated posture of the arboreal primate foot has been greatly overrated. Anyone unfamiliar with the feet of the lower primates, might be led to believe that their feet were fixed in that position. In the orang foot alone has supination become a posture that is determined by definite structural alterations.

In all primates except the orang, the lateral movement of the foot which permits the position of supination, is a free joint action that takes place *beneath* the astragalus and is not one that is conditioned by the relationship of the astragalus to the leg bones. This is easily demonstrated by grasping the lateral facets of the trochlea of the astragalus (in an undried specimen) and moving the foot laterally. Practically the full range of supination and pronation can be obtained in this manner, from a marked inversion of the sole to a mild eversion, with no movement whatever of the astragalus. Variation in the relationship of the astragalus to the leg bones (as determined by the transverse plan of the ankle (tibio-astragalus) joint, is often compensated for, by variation in the medial and outer lateral depths of the astragalus. Consequently the influence of that joint surface (tibio-astragalus) in determining the relative position of the foot to the leg, is negligible because of the wide range of movement of the foot permitted beneath the astragalus. The supinated posture of the arboreal primate foot is principally due to two causes: (1) the over-balance of muscle power by which the stronger flexors and tibials are antagonized by the weaker peroneals and extensors, and (2) the habitual use of a "pseudo-supinated" posture in arboreal locomotion.

A condition similar to the passive attitude of supination of the arboreal foot (*attitude of rest*) is seen in the semi-flexed fingers of the passive human hand. The flexors are always stronger than their opposing muscles and in the attitude of rest they will pull the mobile part into semi-flexion, unless prevented by gravity or some other cause.

During active function, the posture of the arboreal foot is not necessarily a supinated one, but one that is conditioned by the surface which supports the foot. The position of the astragalus upon the shelf-like sustentaculum tali of the os calcis, causes the os calcis to roll inward and downward under bodyweight, so that upon a flat surface the passively inverted foot becomes flattened under the burden of the body. When such a foot is used in travelling along the branches of trees, the position is modified but is not one of true supination. In the grasping posture, the heel is in contact with or positioned above the upper surface of the supporting branch, and the inner portion of the sole as far as the web between the hallux and digits, faces directly downward. The outer portion of the foot naturally drops to conform to the lateral surface of the branch. This latter movement is one which takes place in the smaller tarsal joints and throws the digits into a better grasping posture. If the entire foot were supinated, the heel would necessarily be placed on the digital side of the branch, in which case all the body-weight would fall almost entirely upon the divergent hallux.

Depression of the inner border of the foot under weight has an important effect in that it produces a "stretching" of the flexor and tibial muscles, thereby maintaining a proper "balance" between them and the weaker peroneal muscles. The result of the failure to do this is seen in the orang foot. This ape uses the foot for suspension rather than for direct support. The change in manner of function has removed the influence of body-weight to depress the inner border of the foot and to keep the flexor and tibial muscles "stretched." As the result, the foot has been pulled around into a position of extreme supination which has become definitely acquired by osseus changes. Such a structural condition, however, is unique among the primates and peculiar to this one genus.

Supination as a *functional posture*, is frequently used in arboreal movements, because it is required by innumerable positions of the supporting branches in their relation to the foot. There is but little basis however for considering arboreal supination a structural characteristic except in the case of the orang. In other primates which show frequent use of the suspension type of grasp by reason of a reduction of the hallux, frequent terrestrial visitation, as in the Semnopithecidæ, or the employment of a prehensile tail, as in *Ateles*, have acted to maintain the leg at a right angle, or nearly so, to the plane of the sole of the foot.

MODES AND PHASES OF EVOLUTIONARY CHANGE OF STRUCTURE IN PRIMATE FEET

1. *Physiological Hypertrophy and Atrophy.* One of the principal points of interest which led the writer to undertake this study, was the variation in the structure of the bones of the foot as effected by function in individuals. An increased mechanical use of a part produces hypertrophy of the structure involved, not a distorted, meaningless growth but an economical increase in the structural strength of the part. This change is determined (a) by absolute and unchanging laws of mechanics as they are applicable to the original structure, and (b) in accordance with the degree of the increased demands.

In the opposite direction, the withdrawal of any amount of function from a part results in a corresponding degree of non-development or atrophy, according (a) to the extent of reduction in function and (b) to the degree of previous development; that is, in a matured individual, suspension of function leads to atrophy, while in a growing individual it means a retardation of normal development, although a certain amount of growth will still continue. The same phenomenon applies to the segments which compose a part, and even to portions of those segments. Such changes are shown in the distortion of individual bones of the foot, resulting from an alteration of function due to deformity, and are seen daily by orthopedic surgeons.

Structural alterations are not the result of any variation in mechanical laws as they effect the development of the bone, but are the natural sequence of a disturbance in the normal function in its relationship to the various tissues, whereby the mechanical laws are caused to work habitually in an abnormal or exceptional manner. *The laws are immutable; it is the manner of use that changes*, and structural modifications follow in accordance with the change in function. Hence the only logical interpretation is, that an altered employment of mechanical forces by a structure inevitably causes the original structure to be molded by those forces so that they may work more advantageously in the newly adopted manner; and by the same process, wasting follows non-use.

The actual alterations of bone structure are accomplished by two very simple and well known processes, no matter if the alterations comprise marked changes of the entire structure or merely slight, localized rearrangement of the internal architecture; those processes are, (1) increased growth, physiological hypertrophy, and (2) absorption, physiological atrophy, or diminished normal growth, as the case may be.

It is not the writer's intention to enter upon a biological discussion of the transmutation of species, but in order to define an absolute basis upon which the differentiation of primate feet is shown to be allied to function, a consideration of the relationship of mechanical usage to evolutionary change becomes a necessary part of this study.

"Wolff's Law." In the first place, no other part of the body structure is affected by such violent forces as are exerted upon the comparatively small bones of the foot; in them the entire body weight is concentrated and its great stresses magnified by leverage. The average total of pounds per minute transmitted by the foot bones, is far greater than in any other member of the body. Consequently, if any part of the entire skeleton may be supposed to show the influence of function as a remodelling factor, it would most surely and conspicuously be the feet.

Modification of structure in the living individual to conform with the manner of use has been recognized and accepted by the medical profession as a law, and is known as "Wolff's Law." Such structural changes definitely tend toward improving that structure for a more efficient performance of the altered function. This law applies to changes secondary to disorders, as well as to physiological development of a part due to the long continued use of a specialized function.

For example, the writer had the opportunity of making X-ray studies of the feet of one of our American champion sprinters during his last year in college. Not only were the metatarsal bones fully 20% longer than those of the average individual, but other modifications were to be observed throughout the foot structure, which conformed specifically with the mechanical requirements of that specialized usage.

As the various specialized types of primate feet are studied, it will be found that their individual structural characters are invariably associated with a distinctive manner of use. There is a definite and distinct harmony of both the structural and functional mechanics, just as if evolutionary development were guided by the laws of engineering.

The course of evolutionary change is seen, therefore, to follow the same direction in the specialized development of the feet in species, as in the individual changes produced by mechanical laws. But here another factor is introduced.

Just as an acquired deformity or amputation sustained by an individual has no apparent effect upon the structure of his offspring, so there is no evidence to show that any acquired physiological change of structure may be congenitally transmitted. At birth the individual presents a structure which is typical of his kind, and its form is suited to the range of diversified usage that characterizes the group. Individu-

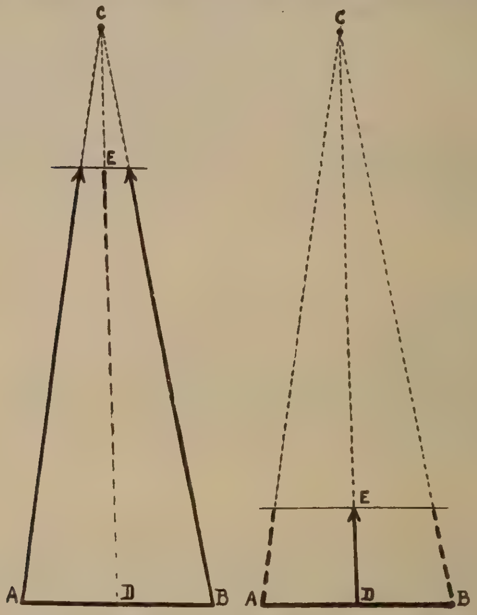

Fig. II. Diag. I indicates the process of Evolutionary Change. Line A B, range of diversified use; C, acme of some distinctive specialization; converging lines A C and B C represent structural alterations progressing toward a specialized type. The scope of diversified use is narrowed as these changes advance, and the characteristic manner of use becomes intensified as indicated by the increasing heaviness of the broken line D E.

Diag. 2 indicates changes acquired by an individual. A B, same; C, the same type of specialization; D is the central or radial point of function. D E represents the progress toward specialization acquired during the individual's life span. Engineering adaptation of structure to conform with function causes the lines A C and B C to converge upon C.

The progress, as regards the relationship of structure and function, appears in both instances to be identical, but, in Diag. I, may be regarded as controlled by structural modifications, while in Diag. 2, by the direct influence of functional use.

al physiological change rarely exceeds a mild modification of the general type because any specializing progress the individual may attempt to exploit, is retarded in proportion to his use of the same functions common to the other members of his group, and because of his relatively short life span.

2. *Restrictive Effects of Specialized Structure.* In viewing the various more highly specialized forms of feet presented by primate groups, a factor may be recognized however, by which evolutionary change operates to follow a course that coincides with the changes seen in the individual.

In those specialized groups the range of diversified usage centers upon some particular characteristic manner of function; the higher the specialized degree of structural development, the more restricted is the scope of diversified use. In other words, a specialized structure debars the employment of unsuitable methods of function and locomotion in proportion to its advance toward specialization.

A triangle might be used to illustrate these points; Fig. II Diag. 1, the base line represents a wide range of diversified use possessed by the early generalized structure; the apex represents the acme of specialization of some particular type; the two sides represent the lateral limitations of functional range, which converge toward the apex, as specializing structural alterations. Their convergence narrows the scope of diversified use, thereby intensifying that particular mode of function, as indicated by the increasingly heavy broken line.

Such a process may be compared to the relationship of function and evolutionary change in a species.

Diag. 2, the same base line is again employed, and the same point used to represent the acme of this same particular manner of function, but the example is now applied to changes as seen in an individual. A point in the center of the base line is taken as a center of functional radiation. The habitual adoption of the distinctive manner of use referred to above, is indicated by a straight line from the radial point to the apex. The workings of mechanical laws immediately begin to modify the structure toward specialization. If continued indefinitely the lateral limitations of function associated with the specializing alterations, would converge upon the apex as in the process described previously.

The direction of both processes is the same; in the first case, however, the changes go on from generation to generation, while in the second it ceases with the life of the individual.

In this manner the course of evolutionary change may proceed and at the same time present a complete harmony of function and structure, as is observed throughout these foot studies; for example, the extremely long scaphoid and os calcis in harmony with the leaping or "hopping" habits of *Tarsius*, and in the leaping *Galago;* the long digits of the arboreal primates, and the short ones of the terrestrial non-grasping groups; the long metatarsals both of the cursorial quadrupeds and of those which are associated with suspension; the metatarsal torsion of the arboreal chimpanzee, which is reduced in the terrestrial gorilla and is almost completely absent in man; the massive development of the heel in the plantigrade gorilla and in man. Other characteristics might be mentioned, but these are sufficient to indicate the harmony of the habits of species and inherited structure.

3. *Effects of Inherited Habits.* Lamarck felt that he had found the key to the transmutation of species in functional variation. His theory stands unproved. When Darwin advanced his lasting explanation of Natural Selection, he recognized other causative factors, placing the effect of inherited usage as second in importance. The modern tendency among the biologists seems to further discredit the direct inheritance of changes acquired by function, and explain the existing differences by Natural Selection and a gradual elimination of the less fit.

Evolutionary ramifications as evidenced by modern life forms are legion; they affect all the senses, processes, organs and tissues that these life forms are heir to. They involve functions or actions of absolutely different natures, mental, reproductive, of sensation, chemical and mechanical.

The struggle for existence is apparently not confined to individuals or species considered as "wholes," but reaches back to every process of evolution, affecting even the smallest parts. Evolutionary changes of the body structure themselves, are shown in these studies to be subject to an election for survival in accordance with their degree of fitness.

If a prenatal change in a primate foot can be useful in the present habits of the species, it becomes accepted, strengthened and developed; if it is detrimental to the efficiency of the foot, theoretically it would be eliminated by Natural Selection.

It is at this stage that the phenomenon enters, which was observed in the individual alterations and termed "Wolff's Law." The postnatal changes (e. g. of the trabeculae and contour of the foot) take place in an adaptive manner so as to approximate toward the optimum engineering conditions for the inherited method of function. Any favorable congenital modification which may have appeared will now be used to advantage. Disuse and the resulting atrophy or lack of development, will be the fate of any undesirable congenital change,—at least until such a time as some variation in habits permits its employment.

A definite source of differentiation is to be seen in this process, for by it the development of a favorable prenatal change is encouraged, becomes manifested in the adult, and may even advance steadily toward a specializing structure as similar habits are inherited by innumerable generations. The less suitable change continues as an undeveloped and subordinated potentiality which, while inherited, may never make its appearance in the mature adult structure. These interpretations, drawn from an analytical study of primate feet, align themselves with the Osborn-Morgan theory of evolution.[3]

Hence there is nothing strange in the fact that in the mechanical analysis of a structure and of its characteristic function, evolutionary development should appear as though it were produced directly by the workings of the laws of engineering. Natural Selection with the development of favorable prenatal characters and the elimination or lack of development of unsuitable ones, accomplishes the same results.

4. *Correlative Changes*. The acquirement of a new structural feature leads to a readjustment of adjacent and even distant parts, as a matter of engineering expediency; or an altered exploitation of certain prenatal characters through a change of habit, affects the postnatal development of all parts involved in the altered mechanical function. Thus, a lengthening of the metatarsals in the ground apes is universally associated with shortened digits; the changes of the body which accompany the erect posture are associated with improved grasping ability of the foot for balancing, and a lengthening of the arms for brachiation; etc. This harmonious correlation of changes in the locomotive structure is acquired because of the influence of uniform engineering principles which favor their separate, but clearly correlated development.

5 *Uniformity of Structure within Species*. With the recognition of the positive adaptation of evolutionary change in primate feet to conform with their distinctive methods of use, uniformity of foot structure among individuals of a species, becomes the expected sequence. The combination of (1) similar structure at birth, (2) the inheritance and exercise of a similar range of habits, and (3) mimicry of offspring guiding the course of development during the plastic stage prior to complete ossification of the bones, would inevitably produce identical results in the matured adult. Points of individual variation are to be seen, but

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[3] Osborn, H. F. *Science, 1879*, N. S., VI, No. 146, 583-587,
Abstr. *Proc. A*. A. A. S., 1898, XLVI, 239.

they are of a mild degree and never sufficient to disturb the dominance of the basic and almost perfect duplication of structural characters common to the species.

DESCRIPTION OF ADAPTIVE TYPES OF FEET OF PRIMATES

The following comments on different types of primate feet are given to show the range of variation that exists within this group. The diagrams have been drawn to a uniform length in order to more clearly bring out the structural differences irrespective of the actual size of the creatures.

The Perching and clinging types, *Tarsius*, *Galago*, *Loris*. Figs. III, IV, and V. All three of these primates are distinctly nocturnal, arboreal creatures of small size, living chiefly among the smaller branches of the trees. Their secure manner of grasp (of the perching or clinging type) may well be considered a necessary part of their equipment, not only for movements in the dark but because of the difficulty in maintaining balance upon the unstable, swaying branches among which they live. The unusual development of the hallux and the two outer digits is as typical of their mode of pedal grasp as is the short metatarsals, for reasons already described. The wide divergence of the hallux is essentially associated with a notable elongation of the peroneal tubercle. Lack of development of the second and third digits is proportionate to their relative non-use, located as they are between the two principal grasping portions of the foot,—the hallux and the fourth and fifth digits. The leaping types are easily recognized when compared with the slowly moving *Loris* with its short tarsus and reduced heel. The tarsal development of the *Tarsius* and *Galago* is a most extraordinary example of the degree to which specialization will remodel foot structures. Primitive characters in these three feet are, the short metatarsals, while in the Loris foot the primitive mid-tarsal pattern has also been retained. The specialized structures are the digits and halluces, the mid-tarsal lengthening of the Tarsius and Galago, and the reduction of the heel in Loris as a retrogressive process due to the feeble leverage effort.

The Lemur. Fig. VI. Throughout the Lemuridæ there is an unmistakable combination of structural characters of the foot which link them together and at the same time show a transitional tendency from a tarsi-fulcrumating to a metatarsi-fulcrumating form. They preserve the essential characters of the clinging forms in the digits and the hallux, a somewhat elongated tarsus and some shortening of the heel, but with a distinct lengthening of the digital metatarsals. The lateral compression of the meso-cuneiform common among this group, is apparently due to the long continued employment of the tightly grasping hold which the wide divergence of the hallux is naturally associated with a transverse pull across the foot exerting strong lateral pressure in this area.

The *Lepidolemur* (Fig. VII) foot is extremely interesting and significant in the more primitive shortness of its metatarsal lengths and the modified clinging grasp. There is a mild mid-tarsal lengthening as compared to the primitive Loris pattern. The movements of the *Lepidolemur* are deliberate, which fact agrees closely with the structural characters of the foot,—a foot of diversified use, not subject to very violent effort, therefore foregoing specialized modifications and retaining many primitive features. The hallux is typical of a strong clinging grasp.

Notharctus. Fig. VIII. The accompanying diagram of the Eocene *Notharctus* is taken from a partial restoration. Two notable features of this species are the shortness and stoutness of the digital metatarsals and the powerful hallux. These, with its other structural characters point very definitely to the clinging grasp, a hold which may very reasonably be expected to typify an animal that had not become orientated to arboreal life to the degree attained by more modern primates. The likeness to the *Lepidolemur* foot is striking, but *Notharctus* does not display the distortion of the middle cuneiform generally observable in Lemuridæ. The mid-tarsal pattern conforms more closely to those of Loris and Potto, which are unquestionably the most primitive of lemuroid types.

Another structural trait which attaches to this ancient primate a similarity in the manner of function with that of modern lemurs, is the concave, entocuneiform facet. This appears to be a mark of the clinging grasp with *tarsi-fulcrumating* leverage, because in such use the major force affecting this joint surface is the transverse pull of the peroneus longus muscle. In the more common type of use among primates, with the fulcrum located at the metatarsal heads or upon the interposed adductor muscle, the body weight causes the greater movements of force to involve this joint more generally in a vertical plane. The concave facet of the cuneiform is undoubtedly the primitive condition; the change to a convex surface must have been accomplished by the conversion of the foot from a tarsi-fulcrumating organ to a metatarsi-fulcrumating one.

New World Primates: The Cebidæ, *Callithrix*, Fig. X, *Cebus*, Fig. XI, *Lagothrix*, Fig. XII, *Ateles*, Fig. XIII. The distinctive characters of the feet are the same in the two smaller genera. They present the hallucial grasp associated with cursorial traits—long digits and metatarsals. There is some torsion of the metatarsal shafts, but it is especially observable in the hallucial metatarsal bone. In the *Callithrix* the fourth digit is longer than the third, undoubtedly due to the small size of its feet compared with the size of the tree branches which usually afford it support. The same condition is seen in other small primates. Its grasp, therefore, appears to be intermediate between the clinging and the hallucial types.

In the *Lagothrix* and the *Ateles*, which are larger animals, a notable difference is presented in the greater length of the second metatarsal over that of the third. Here the humanoid line of weight carriage is established, but the condition does not appear to be as constant as in the anthropoid apes of the Old World. It is well demonstrated however, in the *Lagothrix* (Woolly monkey) and in the *Mycetes* (Howler); another of the larger South American forms, *Ateles*, the more agile Spider monkey, has turned toward a suspension or digital grasp by the foot, as shown by the increased lengthening of the digits and their metatarsals, with an under-development of the hallux and the shorter heel. All of these larger-sized animals have prehensile tails.

The Marmoset. Fig. IX. The rodent-like foot of the Marmoset is distinctly of a cursorial and arboreal type. The lengthened digits show the result of weight suspension by the sharp claws, while the long digital metatarsals are associated both with cursorial movements and with suspension. The under-developed hallux with its relative loss of the power of abductability, demonstrates the complete disuse of the grasping ability, although it retains peculiarities modelled for that purpose, such as the torsion of the hallucial metatarsal, and some curvature of the entocuneiform facet. The short second metatarsal compared with the fourth clearly shows the greater use of the outer half of the foot. This type of foot is unique in the primate order and is distinctly an aberrant specialization which conforms with the animal's habits.

The primates of the Old World show much predilection for terrestrial life. The preference varies in different genera, but on the whole the catarrhine primates are distinctly more terrestrial in their habits than their platyrrhine relatives. This difference in habits shortens the digits of such Old World primates compared with the length of their metatarsals, in contrast to the corresponding ratio in the New World primates.

The Erythrocebus and Baboon. Figs. XIV, XV. These feet are selected to typify the completely terrestrial species. The shortness of the phalanges in proportion to the length of the metatarsals is immediately apparent. The feet have assumed characteristics of terrestrial carnivores, becoming modified for cursorial quadrupedal locomotion on the ground, by this lengthening of the metatarsals and shortening of the digits. There is practically no torsion of the digital metatarsals, but it is very definitely manifested in the hallucial. The grasping function persists and is still used, but no longer as a part of locomotion. The third metatarsal clearly assigns the greatest amount of leverage function to that bone because of its length and proportionately largest diameter. It is evident that these species are unquestionably derived from arboreal ancestors, and that they adopted ground habits before they had changed from the use of the primitive line of leverage to the humanoid line.

The Macaque. Fig. XVI. This type shows distinct ground-ape features in its digital metatarsals but with some torsion of the shafts, especially notable in the second, but distincly less than in the more arboreal *Cebus*. These bones are also longer in proportion to the digits or tarsus, than the metatarsals of the *Cebus* foot. The hallux is well developed and typically formed for the grasping function. The foot is of an arboreal type with terrestrial modifications.

The Langur. Fig. XVII. This foot presents some distinctive traits which agree closely with those of the *Colobus* foot, both animals belonging to the Semnopithecidæ. The metatarsal and digital proportions are very similar to that of the macaque, for the langur is active in the trees and on the ground, but the reduced hallux and slightly longer digits would indicate that a suspension grip was used to a greater degree than the hallucial grasp, as is the case in *Ateles*. The notably longer fourth digit (which was likewise observed in the *Colobus* foot) may be of phylogenetic importance. These animals are of sufficient size to have developed the humanoid line of leverage in the foot when compared to the gibbon. They have not done so, however, but have retained the primitive line. The writer regrets that he has been unable to obtain any definite information in regard to how this very interesting and distinctive type of foot is used.

The Gibbon. Fig. XVIII. This type of foot is highly specialized arboreally, with the humanoid line of leverage completely established and with a high development of the hallucial grasp. It is a foot which can ideally maintain the erect posture of the body by its grasp upon the supporting branch. All the digits and metatarsals are long and the head of the second metatarsal is extended most distally. The pattern of the mid-tarsal bones conforms closely with that of the lower primates, the heel is short, indicating lessened leverage demand upon the calf muscles. The torsion of the metatarsals is carried to a high degree.

The Orang. Fig. XIX. It seems strange that so frequently the orang foot is brought into discussion when evolution of the human foot is being studied. While there exists no question as to the intimate relationship of the orang to the general anthropoid ape group and consequently to man, nevertheless, in so far as the foot is concerned the orang presents an evolutionary specialization which has proceeded directly opposite to the human development. The orang and human feet are valuable for comparison in demonstrating the wide range of possible modification from a generalized anthropoid ape type, but the development of the orang foot is distinctly foreign to the developmental analysis of the human foot. The foot of the orang is a distinctive type of extreme arboreal specialization. The use of the suspension grasp is not only featured in the marked lengthening of the four outer digits and their metatarsals, with a reduction of the hallux, but also by the extraordinary plantar curvature of the proximal phalanges. The atrophy of the hallux has been carried to the extent of frequent absence of its distal phalanx. Earlier use of an advanced development of the hallucial grasp by ancestors of this genus is indicated by the more distal position of the head of the second metatarsal over that of the third and also by the torsion of the shaft of the hallucial metatarsal. Although this torsion is notably present in the hallux, it has disappeared from the digital metatarsals. This loss of torsion is conditioned by the change in the direction of the movements of force accompanying the adoption of the suspension grasp. Extreme supination of the orang's feet has been discussed under the subject of posture. The marked shortness of the heel conforms to the relative disuse of the foot as a lever.

The Chimpanzee. Fig. XX. This animal presents a typical arboreal foot which does not differ greatly in general form from that of the gibbon, except in the massiveness of structure. The foot shows the characteristic conformation for a balancing hallucial grasp, by its humanoid line of leverage with the more distal second metatarsal head, its well developed hallux, and the marked torsion of the metatarsal shafts. The heel is longer than in either the gibbon or the orang, indicating a greater use of leverage effort. An antero-posterior shortening of the mid-tarsal bones (scaphoid, the three cuneiform and cuboid) is distinctly noticeable when this foot is compared with those of the gibbon or of the lower and smaller primates.

The Gorilla. Fig. XXI. The foot of the gorilla presents modifications that are of utmost importance in the study of the evolution of the human foot. The gorilla clearly reveals the predominance of the same arboreal characteristics in foot structure as the chimpanzee. The close relationship of these two animals cannot be doubted, and although the entire skeletal structure of the gorilla definitely supports the conviction of its former arboreal life, knowledge of the modern animal shows it to have given up the habits of its ancestors for terrestrial life.

The gorilla has evidently become a ground-dweller during the time when his increasing bulk unfitted him for life in the trees. Depending upon herbaceous food for sustenance, an adult weighing three hundred pounds or more would be in rather a precarious position while seeking food among the smaller fruit-bearing branches of the trees. To such an animal the ground offers a far more abundant food supply in the way of bulbous growths and tender green sprouts, the procuring of which would be attended with less effort and danger. It may reasonably be considered, therefore, that the actual size of the animal has driven him from the trees. In this case is seen how evolutionary change in the animal has primarily altered its habits and led to an altered exploitation of the feet through the adoption of terrestrial habits.

Undoubtedly the foot of the chimpanzee conserves with very little change, the general characteristics which at an earlier time were common to the feet of both these animals. If this be the case, then the present differences between the two types must be associated with the alteration in habits and would, therefore indicate the effects of terrestrial usage upon an arboreally-developed foot.

Compared in their entirety the two foot skeletons show a greater massiveness of bone in the gorilla foot, corresponding to the increased bulk of that animal, and a shortening of the entire forward half, for the gorilla foot indicates less active and more ponderous movement. The plantar curvature of the phalanges and metatarsals of the chimpanzee befitting its greater use of grasping, is diminished in the gorilla.

The phalanges and digital metatarsals have shortened in the gorilla foot until the head of the second metatarsal is on a line, or nearly so, with that of the first metatarsal. This fact, coupled with the greater bulk of the gorilla's second metatarsal over the three outer ones and the powerful development of the hallucial metatarsal, would clearly demonstrate that the terrestrial line of leverage is located between these two bones. The torsion of all of the metatarsals is greatly reduced in the adult gorilla foot, so that the plantar surfaces of the digits are presented more flatly to the ground, as contrasted with the laterally-turned digits of the chimpanzee. (See Part I).[4]

There is considerable reduction in the peroneal tubercle of the first metatarsal in the gorilla foot. This reduction permits that bone to be adducted to a position parallel with the second metatarsal, while in the chimpanzee this bony protuberance obstructs an adduction to within an angle of about 30°.

The anterior facetal portion of the gorilla's inner cuneiform bone is much more prominent than in the chimpanzee foot, but this, however, is apparently a reinforcement of this area against hyperextension of the first metatarsal under increased leverage usage in the larger terrestrial animal.

The mid-tarsal segment shows the same anteroposterior compression which is seen in the chimpanzee foot, but here it is carried to a greater degree and with a marked shortening of the neck of the astragalus. The body of the latter bone is greatly flattened and distorted as if by the body weight.

The notable lengthening and strengthening of the gorilla's os calcis implies two things: (1) a truly plantigrade posture of the foot, and (2) increased use of the function of leverage. The lengthening of the heel compensates for the relatively weak calf muscles in furnishing power for movement of its ponderous weight.

The exercise of foot leverage varies greatly, not in manner as much as in degree. This variation can be recognized comparing the gait of two human pedestrians, one having normal feet, while the feet of the other are badly flattened. The former walks with a graceful, easy carriage and without apparent effort. The center of gravity of the body is kept slightly advanced and the impulse, which is given to the body weight by each foot, seems almost automatically to carry the foot forward also into position for its next step. The other pedestrian shows a very different gait. His center of body weight is not carried in such an advanced position and instead of being impelled directly forward, it is merely shifted obliquely from one foot to the other. Each foot is raised and brought forward by voluntary effort to receive the obliquely-shifted weight from the other. There is no grace, nor apparent indication of active leverage in his movements, merely a shifting of weight. If he attempts to hurry, the apparent expenditure of effort is accompanied with an awkwardness of movement that is almost as painful to the observer as it must be to the pedestrian's own sensibilities.

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[4] Morton, D. J., Amer. J. Phys. Anthrop., 1922, V, No. 4, 305, 336.

The latter example of the act of terrestrial leverage may be considered comparable with the early stages of leverage development. Normally the function is highly developed in modern man, because his is a foot specialized for this manner of use, but the great ape foot is incapable of such efficient leverage action.

The short heel of the chimpanzee foot indicates the low grade of leverage effort that characterizes the arboreal foot. In the gorilla, however, a marked difference is found, both in length and in massiveness of the heel. Increased massiveness can be accounted for by the plantigrade posture, but the lengthening of the heel is obviously the result of improved leverage action. Evidently the first propulsive efforts were weak and associated with a shifting of weight from one foot to the other. Continued exercise in a group of active and energetic animals, however, would stimulate the development of the leverage action with a subsequent lengthening of the heel.

Another very significant difference presented by the gorilla foot is the early development of the elements of a longitudinal arch. This structure, as manifested in the human foot, is a distinct product of terrestrial leverage function and has been discussed in detail in a separate article.

Examination of several adult native gorilla feet shows that there is a considerable range in degree of the differences between the gorilla and chimpanzee feet as pointed out in the foregoing comparison. This fact does not discredit the value of these observations, but, to the contrary, it more definitely asserts the intermediate structural relationship of the arboreal anthropoid foot and the human terrestrial form, and strengthens the evidence that the gorilla's modifications are comparatively recent acquirements caused by its change of habitat.

THE HUMAN MODIFICATIONS

The distinctive modifications of the gorilla foot compared to man's, may be looked upon as early terrestrial changes because arboreal characters have been retained to a notable degree. The alterations, however, are clearly parallel with the development that led to the human type of foot. The foot of modern man shows an advanced stage of the changes which have been begun in the gorilla foot, and also such additional differences as are the results (1) of its high degree of specialization, and (2) of having started its terrestrial development from a more primitive type of arboreal foot, than did the gorilla.

The Digital Area (excluding the hallux). The phalanges are very short, especially the middle and distal ones; their plantar surfaces are directed completely downward. The variation in the respective lengths of the digits as compared to those of the apes, has been considered in Part I of this study.

The Metatarsal Area. Metatarsal torsion, which was reduced in the gorilla foot, is practically absent in man, although it persists to a mild degree in the first and second metatarsals (See Part I). These bones are shorter in proportion to the length of the foot than those of the chimpanzee, which fact conforms to a discontinuance of the use of grasp and frequent suspension, but they are of practically the same relative length as those of the gorilla.

The Hallucial Member. This has become a particularly important structure in the human foot. Its size clearly indicates the amount of burden thrown upon the first metatarsal when it is compared to the four outer bones; as also does the marked enlargement of its two phalanges. Ten degrees of torsion is practically constant in the human first metatarsal, and although it is held fixed in complete adduction, it retains all the musculature that exists for the grasping function as manifested by the arboreal primates.

The Mid-tarsal Segment. This area presents some of the most important but less conspicuous differences between the human and the great ape feet: (a) the flattening of the entocuneiform metatarsal joint, (b) the obliteration of the scapho-cuneiform fossa and the difference in the pattern of the mid-tarsal bones.

Although the entocuneiform facet is a flattened one, its surface presents the same cylindrical convexity that prevails among primates generally. The possibility that such a condition could have been derived from a more rounded joint surface has been discussed in Part I. The same flattened type of joint is seen in the marmosets, whose associated torsion of the first metatarsal indicates an earlier ability to grasp. This ability could have been possible only when a well-rounded facet permitted free abduction of the hallux. Hence it is apparent that a flattened facet naturally follows the abandonment of the grasping function.

The scapho-cuneiform fossa is of interest as evidence of Nature's economic modelling of bone structure to permit direct, unswerving channels for the transmission of force. A gradual obliteration of this fossa can be observed as the stages are followed from the clinging type of foot, through the hallucial grasp to the gorilla foot and finally to man's, Fig. XXIV. In the clinging tarsi-fulcrumating foot the stresses form a roughly shaped Y with the stem representing the outer cuneiform, and the divergent arms representing the ridges through which run the strong lateral stresses from the hallux and the outer metatarsals due to the tight grasp. In the macaque foot the strong grasping stresses are reduced and the fossa is less strongly defined. In the great ape the stresses have been moved toward the inner border of the foot with increasing shallowness of the fossa. In man it has become nearly obliterated.

The pattern of the human mid-tarsal bone resembles more closely that of the gibbon or of the lower primates than of the gorilla or chimpanzee. It does not show the anteroposterior shortening that characterizes this area in the latter animals. The significance of this difference will be discussed later.

The Posterior Tarsal Segment. The heel of man is massive and deepened vertically, ovoid in section instead of round as in the gorilla's. It is a heel that has been modified for weightbearing and also to sustain the strong upward thrust from the calf muscles in violent leverage effort. It is shorter than the heel of the gorilla thereby decreasing in power of leverage, but this is compensated for by the stronger development of the human calf muscles. The joint surfaces of the os calcis which support the astragalus, present a difference in man and the great apes, which is of great importance in analyzing the course of the human evolution. In man these facets are nearly level, but slope somewhat forward and mildly inward. In the great ape feet, the slope is abruptly inward, downward and obliquely forward.

EVIDENCE PERTAINING TO THE CHARACTERISTICS OF THE PREHUMAN FOOT

The above analysis has been undertaken to establish, if possible, the true relationship of structure and function in evolutionary development of primate feet. The evidence obtained from fossil and living forms may be summarized as follows:

1. That the progressive changes which have occurred among primate feet have tended to follow several divergent courses of specialization.
2. That many less advanced stages of evolutionary change along these special lines of adaptation are observable along existing primates.
3. That the alterations of structure are invariably concurrent with modification of functional demands, such as altered habits, increased weight, etc.
4. That in every phase of progressive change, structural alterations

represent the best examples of economy of effort and material afforded by the inherited form, that is, they proceed in accordance with the best engineering principles.

5. That primate feet are entirely free of a single aberrant development which would discredit the conclusion that all recognizable differences in structure are correlated with some constant or habitual alteration in functional (mechanical) exploitation.

6. Adaptability of the structure in the individual to the mode of function operates to purge the foot of any chance modification foreign to the existing demands of its habitual function.

Hence the primate foot may be regarded as an exceptionally reliable historical record; it is remarkably susceptible to the modelling influences of individual function, but its peculiar characters are acquired only by notable and enduring events in the life of the genus.

Since the numerous differences in primate feet may be accepted as a record of events in the life of the genera, then the events, and possibly their sequence, will be uncovered by a proper mechanical analysis of those differences, from the viewpoint of mechanical requirements. Such an analysis can be expected to disclose the process of change in the foot of man and to reveal facts regarding his early history. The accuracy of the interpretations would depend entirely upon the ability of the analyst to recognize and weigh the value of the essential points of characteristic difference, as well as to interpret the application of the engineering laws involved.

As the chief purpose of this study has been to trace out the evolutionary development of the human foot, the writer has attempted to make such an analysis and gives his interpretations and their reasons in the succeeding part. Because the foot is not an entity by itself, but reflects and is intimately correlated with happenings that involve the genus, all evidence bearing upon the ancient life of man and his structure, and upon the closely related primates are necessarily drawn into consideration.

Basic uniformity of structure and the common possession of distinctive points of similarity has proved the closer relationship of man to the great ape group than to any other of the primates. This means that there was an interval of common ancestry in which they were all contained in a single genus of uniform structure. The existing differences are differences which have been acquired by the various member groups since that period of mutual parentage.

The totality of similar characters plays its part chiefly in establishing common relationship. But in the effort to work out the separate history of the individual groups, and the relationship of each one to the others, the *points of difference* and a proper determination of the proportionate value of each of those differences, become the guiding factors. Among such differences, there are two that appear quite inconspicuous when the human foot is compared with those of the gorilla and chimpanzee; (1) the difference in the mid-tarsal pattern and (2) the slope of the calcaneal facets. (Figs. XXV, XXVI).

These two differences are of greater significance, however, because they lie in the central "sheltered" portion of the foot where changes are conservative and, therefore, of correspondingly greater importance.[5]

The mid-tarsal pattern of the gibbon resembles that of the monkeys; in the great apes it is decidedly shortened, while man appears with the more primitive pattern. Could man have had such a shortening and then have recovered the former length through the exercise of leverage? This would be contrary to the observations made in mammalian feet (see page 12) which show that the lengthening from leverage is largely confined to the metatarsal area, consequently it would be most improbable for a lengthening of the midtarsals to occur without an even more conspicuous lengthening of the metatarsals. Apparently man could have avoided this shortening only by having separated from the great ape stock before it had occurred.

What produced this shortening in the great apes? Once more observations among the mammals give a suggestion; the attainment of a greater body bulk. As man has also attained this greater bulk of body it is evident that he gained this great increase in size after he had adapted the use of his foot so that the crushing effect of body-weight would not be exerted upon the mid-tarsal area. This could only have been accomplished by the use of the heel for the transmission of a large portion of the body-weight, which in turn would have been possible only with an associated use of the erect posture, whereby the center of gravity of the body was located at a point perpendicularly between the heads of the metatarsals and the heel. Therefore, the retention of the more primitive mid-tarsal pattern supplies evidence of three phases in man's history: the early attainment of the erect posture, separation from the great ape stock before it had attained its modern large size and the early adoption of terrestrial habits.

The antiquity of the erect posture has already been indicated by palaeontological evidence and probably dates back to the beginning of the Miocene and earlier. At that time the great ape stock was of a relatively small size for it was shortly before that period that the hylobate branch was given off. Hence it is possible to locate a stage when (1) the group had not acquired great body bulk, (2) the mid-tarsal pattern was evidently of primitive type and (3) the erect posture was habitually used.

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[5] W. K. Gregory, The Orders of Mammals. *Bull. Amer. Mus. Nat. Htst.*, 1910, XXVII, 111,112.

Relics of the extinct species of large anthropoid apes have been found in the Lower Pliocene and in the upper and Middle Miocene. As certain of these extinct species had acquired the size of the modern anthropoid apes, the period of great increase in body bulk occurred apparently during the later part of the early half, or the middle half of the Miocene, and afterwards remained more or less stationary.

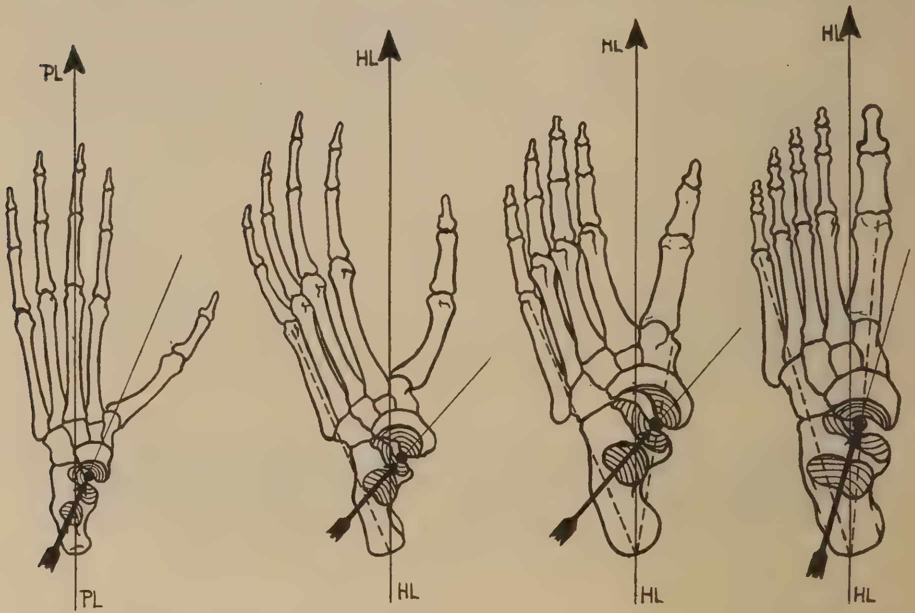

Fig. XXVI Slope of the Calcaneal Facets.
Macaque. Chimpanzee. Gorilla. Homo. PL Primitive line of leverage. HL Humanoid line of leverage.
The slope of the facets and direction of their thrust of body-weight is indicated by the heavy arrows. The dot represents the lowest area in the joint, the point of gravitation.

The Calcaneal Facets. The second important difference is the slope of the calcanel facets as presented by the feet of man, in contrast to that of the anthropoid apes, (including the gibbon, but not the orang). The abrupt inward inclination of these facets in the great apes is evidently an accompaniment of the balancing foot grasp with the humanoid line of leverage, for it is found to be much less sloping in the lower primates (Fig. XXVI). The importance of this character lies in the fact that these sloping facets act as an inclined plane to deflect the body weight upon the inner border of the foot. It is this structural character that has caused the increased development of the first and second metatarsal bones in the gorilla by leverage action, and it may also be regarded as an essential condition to the early human evolution of the foot. Through action of these sloping facets the postural supination of the arboreal foot becomes obliterated in terrestrial locomotion.

The Longitudinal Arch. The prevailing opinion that the longitudinal arch was derived from an earlier supinated posture of an arboreal foot is unquestionably an erroneous one. Such an interpretation cannot survive a careful and comprehensive analysis of the structure and mechanics of the anthropoid-ape and human feet. In fact the most important phases of the human development are bound up with the arboreal arrangement of this joint which destroyed the supinated posture before the formation of the longitudinal arch began.

Sir Arthur Keith[6] and Professor Franz Weidenreich[7] have recently published articles favoring the direct transition of the supinated posture to the longitudinally arched conformation of the human foot. Their interpretations are contradicted by a number of evident facts:

1. The combined power of all the supinating muscles is incapable of sustaining the foot in the supinated posture under the continued stress of body weight, unless the foot is so completely supinated that the weight is borne on the outer border of the foot, as in the orang.

2. The arboreal foot is a very flexible structure compared to the rigidly arched foot of man. All Army and medical statistics show that even the modern rigid human foot shows a marked tendency to become pronated—flatfooted—that is, to roll inward under body weight. If such is the case in the rigid structure, there would be little chance for the flexible arboreal foot to maintain the supinated attitude,—especially with the weight strongly thrust against the inner border by reason of the slope of the calcaneal facets.

3. In the arched human foot the first metatarsal bone acts as a buttress to maintain the contour of the arch. It is fixed in this position by the plane of its basal joint and by strong plantar ligamentous tissues. The hallucial metatarsal of the arboreal foot cannot be depressed because

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[6] Keith, Arthur—Hunterian Lectures, *Brit. Med. J.*, Apr. 21, 1923.
[7] Weidenreich, Franz—AMER. J. PHYS. ANTHROP., 1923, VI, No. 1.

it would necessitate a separation at its basal joint (Fig. XXVII), the plane of which is perpendicular to the long axis of the foot; if such movement were possible the hallux could offer but little resistance to body weight in helping to maintain the foot in a supinated position.

4. If the supinated posture had been retained and the inner border of the foot kept elevated, then the outer border of the foot would have become the actively functionating part and the inner border would have been held in a completely useless position. The result would have been an atrophy of the inner border and a hypertrophy of the outer. The fifth toe would have become the great toe and the first toe the small one. Talipes equino-varus (club foot) is a parallel example. Figure XXIII is a sketch taken from an X-ray picture of the results of this condition in a young adult. At birth there was little deformity except for the supinated posture. If the altered development shown in this case is the result of only twenty-five years of walking on the outer border of the foot, it is difficult to predict what results would have been produced if that manner of locomotion had been started with the origin of man.

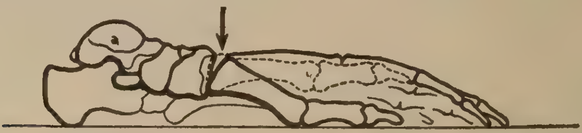

FIG. XXVII Chimpanzee foot in mild supination, showing separation of the basal joint of the hallux (indicated by arrow) necessary to depress that member to the ground. The natural plane of the hallux when the foot is held in this position, is drawn in broken lines.

Factors which condemn the theory of the derivation of the human arch from a previous supinated posture, lend themselves quite as forcibly toward a very natural process of development which utilizes the inward thrust of bodyweight to cause hypertrophy of the inner border of the foot (as is already seen in the gorilla) and to build up the arch as a completely new and distinctively human creation.‡

The direction of the inward slope of the calcaneal facets of macaque, chimpanzee, gorilla and man is indicated in Fig. XXVI by the heavy arrow crossing the facets. Its wide lateral thrust in the two great ape feet is very apparent when compared with that of the macaque or man.

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‡*Note.* An article by the present writer on "The Evolution of the Longitudinal Arch of the Human Foot," published in "The Journal of Bone and Joint Surgery," No. 1, Jan. 1924, considers in detail the evolutionary development of the longitudinal arch and the fixed adduction of the hallux. Both phenomena are shown to be intimately associated with, and acquired by the application of the mechanics of leverage.

Arboreal Specialization of the Great Apes. There is one other point to consider before an attempt is made to determine the characteristics of the ancestral great ape stock at the time of human origin. The early primates had comparatively short extremities of equal length. In the present quadrupedal monkeys the limbs are long. In man who has reached an advanced stage of development as a terrestrial biped, the legs are much longer than the arms; this is the obvious result of the exclusive use of the legs in locomotion and the disuse of the arms for that purpose. In the great apes the reverse condition obtains—the upper extremities are much longer than the legs. Here also is a condition which can be laid to the manner of locomotion, for the great apes are essentially brachiating animals and the legs are used more passively as a mere means of support rather than for locomotion. The long legs of the gibbon would indicate that the great ape stock had at some time acquired equally and fairly long upper and lower extremities. This animal is particularly an arboreal brachiating animal, and its bipedal locomotion is so relatively incidental as hardly to be conducive to a marked degree of leg development. The shortness of the legs of the larger apes may therefore be regarded as secondary with some degree of assurance.

As the human and ape developments are traced backward, they definitely lead to a stage when the arms and legs were of practically equal length. An equal length of the arms and legs, (or not more than a slightly greater length of the arms) is sufficient to indicate the habitual use of brachiation which is naturally associated with familiarity with the erect posture. Consequently it is reasonable to allot a habitually erect posture to the great ape stock at the time of human separation.

This induction is strengthened by Prof. O. Abel's[8] analysis of the femur of *Dryopithecus rhenanus* of the lower Pliocene. To that animal he ascribed a more frequent use of the upright gait than is presented by any of the living anthropoid apes. His analysis points definitely toward a more perfect and habitually erect posture in the ancestral great apes and indicates the retrogressive changes in the modern animals due to a protracted arboreal life.

Indicated characteristics of the original human stock. All the lines of evidence furnished by a comparative analysis of the feet and of the specializations of the locomotive apparatus of man and the great apes when traced backward, converge toward a very definite point or stage.

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[8] Abel, O.—Lehrbuch der Palæozoologie, Jena, 1920., 457.

It was a stage prior to the development of gigantism, but one in which the erect posture had been well established.

A hypothetical description of a member of the common ancestral group is as follows:

1. About the size of the modern gibbon but stockier in build.
2. Arms and legs of equal length or nearly so.
3. Active and agile in its movements, freely brachiating after the manner of the chimpanzee, but not as the modern gibbon.
4. Completely quadrumanous with well developed pollex and hallux.
5. Erect posture habitual, bipedal movements in the trees and on the ground, as in the modern gibbon. (The extended legs and the adaptation of the nervous system had unfitted it for quadrupedal locomotion.)
6. Cranium gibbon-like.
7. Tailless; the ischial pads had probably disappeared.

This interpretation of the general characteristics of the great ape stock at the time of the human origin, affords a point of radiation from which the different developments could follow their separate courses in a natural and logical manner. It occurred after a sufficient interval had passed since the separation of the gibbon, to have permitted such modifications—probably glandular—that would insure the common development of gigantism in the various offshoots. The agility that is naturally associated with a slighter build, was still preserved. Well advanced adaptations of the entire skeleton for the erect posture made bipedal locomotion a natural choice on visitations to the ground.

There was no such thing as a semi-erect posture at that time, for the equal length of the upper and lower extremities demanded a choice of a quadrupedal or an erect carriage of the body. Reasons given above would effectively prompt the use of the upright posture.

The modern characteristics of the human frame that pertain to locomotion definitely conform to results that may be assigned only to a combined effect of terrestrial life and erect posture. Viewed conversely, it is obvious that the human modifications of structure could not have been begun until this combination of factors had been established. It becomes evident, therefore, that the habitual adoption of ground habits by a certain group from the great ape stock was at least one of the most important factors in segregating them from others of their kind, and also in establishing conditions which were essential to the ultimate appearance of mankind.

Had the group remained arboreal for an indefinite period, its inclination to adopt ground life would have diminished correspondingly because its structure would have followed the specialized arboreal changes now seen in the great apes. To the same degree, the distinctly human characters would have been retarded or prevented.

The period of maximum opportunity for the beginning of the human development was presented in the relatively small-sized agile stage, after the habitual use of the erect posture had become established. The early characteristically human modifications were instituted, and a definite separation from the great ape stock accomplished, when ground life was adopted by a group which was to become the ancestors of man. The change to terrestrial habits could hardly be viewed as an immediate one, but undoubtedly it progressed rapidly.

The total evidence indicates that the early half of the Miocene was the time of this separation.

Characteristics of the early prehuman foot. Conforming to the interpretation of the habits and structure of the inferred stage described above, the foot would be a generalized great ape or gorilloid type. The mid-tarsal pattern would be like the gibbon's but in the proportion of its segments would resemble more closely a small chimpanzee foot. The bones would be of the proportionate stoutness of the macaque's. The humanoid line of leverage had been established, and the heel was of moderate size. It was a flexible foot and presented the *postural* supination typical of arboreal primate feet.

EVOLUTION OF LOCOMOTION IN THE PRIMATES

As the various types of ancient and modern primate feet are analyzed and the modifications of their general structure are compared, a very definite course of evolutionary progress in locomotion can be followed leading from the primitive type to that of man. All other modern specialized types of function can also be traced back to the same source, for the various intermediate stages of functional development have been retained by living species. The succeeding paragraphs show in a tentative manner the writer's interpretation of the relative time and sequence of the appearance of functional and structural changes. Such modifications have not occurred in all species synchronously, but just as some modern forms have changed but little from the primitive type, so the changes have been rapid in some and slow in others.

Human evolution has been divided provisionally into fifteen stages, beginning with the opening of the Eocene era. The following interpretation is practically identical with the analysis previously made by Dr. Gregory.[10]

1. About that period the primates were arboreal, quadrupedal creatures, small in size. They had originated from small terrestrial animals which had previously adopted arboreal habits through some unknown combination of circumstances. Arboreal modifications had already taken place, but the creatures were not highly adapted or equipped for this mode of living, consequently they were timid and slow in their movements. The power of grasp had developed but the grasp was an inefficient clutching one, owing to the primitive shortness of the digits. Their locomotive structure showed equally short arms and legs, short metatarsals and digits with a well-developed hallux. Such Eocene primates have been described from fossil remains by Prof. Gregory.

2. Imperfect adaptation for arboreal life was responsible for a clutching or clinging grasp which stimulated a development of the digits (especially the two outer ones) and the hallux. The metatarsals remained short. With the greater security resulting from a firmer grasp, the movements became freer and more active. Locomotion was of a "flowing" and of a climbing type in which the greater portion of active work fell upon the legs, while the anterior or upper extremities were principally used for security and temporary support. Consequently the legs showed the earlier increased lengthening and development. The foot's tight clinging grasp made necessary a tarsi-fulcrumating form of leverage, as described on page 9. Modern evidence of this stage is seen in certain very primitive foot characters of the Loris and Potto, which have been retained owing to their slow, cautious movements.

3. Orientation to arboreal life had now become definitely manifested by adaptations for active movements. The clinging grasp had been loosened but was still a cautious one. This change permitted a gradual displacement of the leverage fulcrum of the foot from the tarsal area to the heads of the metatarsals, causing a lengthening of the latter bones. The hallux was more strongly developed. The long legs had developed from previous climbing movements. Increased familiarity with arboreal life combined with the security of a well-developed grasp led next to leaping movements. Re-adjustments of the nervous system for more efficient muscle coordination and for maintaining balance, allowed the beginning development of arboreal cursorial movement without the use of foot grasp. Habitual squatting began.

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[10] Gregory, W. K. Mem. Am. Mus. Nat. His. 1920 III Pt. 2, 232-241. J. Dent. Res. 1920, II. Nos. 1-4, 1921, III, No. 1.

This stage, which may be regarded as starting with the beginning of freer and more active arboreal movements, was the radiation point of the greatest number of diverse types seen to-day. The most representative forms known of this stage are the Lepidolemur and Notharctus feet. The radial developments are toward:

A. Old World types of primate feet without a lengthening of the mid-tarsus thereby indicating a more direct adoption of metatarsi-fulcrumation.

B. Leaping tarsoids—Microcebus, Galago, Tarsius with markedly elongated tarsus.

C. Lemuroid forms, cursorial quadrupeds, Lemurs with slightly elongated tarsus.

D. Lemuroid forms, developing marked leaping ability, with slightly elongated tarsus. Indrisinae.

E. New World primates. Notharctus seems to present a primitive type intermediate between the two lemuroid forms, that places it in line with the subsequent cursorial locomotion of the American primates.

4. Active cursorial locomotion in the trees now became dominant over the earlier climbing movements and brachiation was started with a consequent lengthening of the arms. The cautious grasp gave place to the cursorial posture of the foot (the line of leverage following the middle metatarsal bone), except among the smaller and swaying branches: The first metatarsal became remodelled to turn the hallux toward the digits, its former wide abductability becoming reduced. The squatting habit was definitely established.

5. The early Oligocene anthropoides may have presented a manner of locomotion which conformed with that of many modern types of monkeys. A characteristically cursorial method was fully acquired coupled with a moderate amount of brachiating movement. The latter method had a specific action in lengthening the arms toward equal proportions with the legs and also in promoting increased use of the erect posture. In the foot the metatarsals became longer and their torsion more apparent, while the hallux definitely lost its extremely wide abductability.

Modern examples of stages 4 and 5 are the Old World and New World monkeys. During these stages the ancestors of the modern ground apes became terrestrial, thereby acquiring cursorial quadrupedal modifications of the feet while still retaining well developed arboreal characters, and the rodent-like foot of the Marmoset developed.

6. The next stage of progress in the great ape line was an adoption

of the humanoid line of leverage in the feet. In them brachiation was gradually predominating over cursorial locomotion and the use of the erect attitude in the trees became more and more habitual. The arms were of nearly equal length with the legs, because of their free and active, but not leaping brachiation, as seen in the modern gibbon. On the ground their movements were quadrupedal and cursorial but were becoming somewhat awkward because of the gradual extension of the leg upon the body, due to the use of the erect posture in the trees.

7. The Oligocene period witnessed a great step in the development of the anthropomorphous group. That advance consisted of the acquirement by that group of such adaptations of the body for the erect posture, that reversion to a quadrupedal method of locomotion became practically an impossible chance. The legs had become so extended on the body that a quadrupedal gait on the ground was very unnatural and awkward, although it may have been the most rapid in case of necessity. Alterations for the erect attitude had reached an advanced stage throughout the entire skeleton and involved the internal organs and soft tissues. Also there had occurred a complete adaptation of the nervous system. On the ground, ordinary movements probably compared to those of the modern gibbon—short, quick runs in an upright position, but squatting upon coming to a halt. The tail had disappeared and the arms and legs were of equal, or almost equal, length. The relative proportion of the digits of the hand and of the pollex was about that of modern man. The general appearance of the foot probably resembled most closely that of a large macaque. *Propliopithecus* of the Lower Oligocene of Egypt, although known only from a fossil jaw, was probably a typical representative of this group. The Hylobate branch seems to have started here.

8. This stage occurred about the end of the Oligocene or the early part of the following Miocene era. Structural changes consisted of a continuation of those which characterized the previous stage and with one very additional distinctive feature—a modification of the ductless gland complex, which insured a great increase of statute in future offshoots. From this stage the orang is carried and also *Sivapithecus* as an intermediate form. The main stem continued as *Dryopithecus*.

9. The *Dryopithecus* stage was a continuation of the last in the increased structural adaptations for the erect posture. During this period the chimpanzee branch may have been given off and other branches leading to intermediate fossil forms. The members of this

early *Dryopithecus* group were still comparatively small and slender and very agile in their movements.

10. From this small-sized *Dryopithecus* stem the prehuman off-shoot became distinguished by its definite adoption of terrestrial life. Their preference for the erect attitude had become firmly instituted. The lowering of the heel to the ground for weight-bearing and its resulting hypertrophy, was one of the earliest human changes. Other alteratious in the direction of structural modification was a cessation of arm lengthening and a return to greater development of the legs. Shortening of the toes naturally followed the giving up of arboreal life.

11. Judging by the size of the teeth of the known fossil apes, it would seem that increase in body-bulk was comparatively rapid after the human separation and had attained modern proportions in some species by the close of the Miocene period. The human branch was undoubtedly affected likewise. Terrestrial alterations of the foot and probably of the entire skeleton as well, were quite rapid and gross at this early stage of human development. The legs became longer, bipedal stance and locomotion more perfect.

12. This stage represents the early half of the Pliocene. It was probably distinguished in mans' history by his gradual elimination of bestial characters and by a steady progress toward human stature. His cranium was undoubtedly small and his mentality extremely low. Were it not for changes in his general structure, and especially his terrestrially modified feet, it is hardly likely that he would be recognized as a human precursor.

13. The most conspicuous change during the latter half of the Pliocene was the enlargement of the cranium. The early *Dryopithecus* skull was undoubtedly a gibbon-like model, as a primitive type. When man's origin is placed at a point where primitive features prevailed so generally, it is not strange that the cranium of *Pithecanthropus* is described as seeming to belong to a very large gibbon. That the skull is so small when compared to the modern human skull is not surprising when the fact is realized that cerebration was very slow and sluggish at first; but exercise of the new-born mental faculties multiplied their capabilities more rapidly, as by geometric progression, consequently the size of the brain, enlarging slowly at first, grew correspondingly faster. It is quite likely that the greater part of skull enlargement as presented by *Pithecanthropus* was acquired only during the latter part of the Pliocene age. This representative of early man possessed a characteristically human femur, which fact definitely gives evidence of the antiquity of combined terrestrial

and bipedal usage and clearly aligns itself with the writer's interpretations.

14. Here again the most conspicuous change lies in the skull. The marked development of the Neanderthal skull compared with that of *Pithecanthropus* apparently occurred during the relatively short Pleistocene period, and seems to accord with a curve of increased cranial growth and activity of thought production comparable to geometrical progression until the brain had attained modern size; from then on, enlargement of the brain with its primitive convolutions gave place to increasing complexity of its convolutions and structure.

In regard to the locomotor apparatus, the incompletely extended legs of the Neanderthal race when contrasted with the fully erect stature of the Cro-Magnon who immediately followed, places the former in a distinct line. How far back the Neanderthal line extended as a separate branch it is impossible to say at present. In consideration of his retention of the distinctly ape-like character of parts of his structure it is possible that the split may have been ancient. His foot clearly shows primitive traits, but it is a completely developed human foot. Terrestrial changes in the feet of the early representatives of the human stock were rapid and coarse. As the foot approached a higher degree of specialization the changes became slower and the foot assumed a more refined appearance.

15. The final stage pertains to *Homo Sapiens* as a modern species.

CONCLUSION TO PART II

Primate feet afford an unusually excellent opportunity for the study of the relationship of structure and function in evolutionary change, because of the wide diversity of specialized types contained in the primate feet, and because of the numerous less advanced or intermediate stages presented, by which the progress of divergent developments are revealed.

The writer has been fortunate in having had an extensive opportunity of observing and studying, in the practice of orthopedic surgery, alterations of bone structure in human individuals which were associated with variations of function. It is doubtful if any other field of study offres such continuous and intimate contact with this phenomenon. Such alterations of structure are definitely and convincingly produced along strictly engineering lines, according to the manner of the habitual employment of mechanical forces.

In the subsequent analysis of primate feet it was found that harmonious correlation of structure and function is the outstanding feature in the many differences, just as was the case in the individual. All structural changes are clearly found to be acquired in a manner which conforms to the principles of engineering whereby maximum efficiency is associated with a minimum of necessary material. Specialized forms demonstrate this most conspicuously. Evolutionary modifications of foot structure for some particular mode of function, inevitably follows the direction of the course of change that would be produced in an individual's feet by the habitual use of that same mode of function. Since in the latter case there is a superabundance of incontrovertable evidence that the alterations are the result of changed usage and are guided by engineering principles, consequently the controlling influence of the same principles are clearly disclosed in an analysis of the evolutionary differences in primate feet.

This apparent domination of mechanical influence in the various remodellings of primate feet is indicated by the facts that those differences conform definitely to the mechanics of their characteristic mode of function, and the absence of any differences which do not. That this dominance is not to be observed to the same degree in other parts of the body frame is logically explained by the reason that none of the other parts transmit mechanical forces comparable with those of the foot in their combined strength and constancy. Hence, it may be concluded that the mechanical influence of function dominates evolutionary change in proportion to the intensity and continuity of the forces involved, and also that mechanical control is *only one* of the factors that effect evolutionary change.

Through the uniformity of engineering laws, modifications of foot structure are invariably correlated with changes in other parts of the body frame when both are associated with, or involved in, a single change of habit; as in the assumption of erect posture, or when some change of a different nature in the creature leads to a modification of the mechanical forces involving the feet, such as increased size, or outside environmental factors. Therefore, evolutionary development of foot structure is more than a simple change of the foot's contour,—it is a lasting record of some event in the history of the genus, which event has a duplicated record in the correlated changes elsewhere in the body frame.

The primate order presents a number of divergently specialized types of feet by which progressive evolutionary development may be traced back to the primitive form by the existence of numerous intermediate types. In most of these lines of development the progress has been simple and direct, because the animals have merely specialized as arboreal quadrupeds. Man shows the most complicated sequence of changes because three profound factors led, in turn, to extensive readaptations of the feet; they were: (a) increase of size, (b) erect posture and (c) the adoption of terrestrial life.

Many of the modifications resulting from these factors were acquired by the ancestral great ape stock prior to man's separation; in fact, only those changes which have succeeded the adoption of terrestrial habits may be regarded as actually human characteristics.

Starting from the very primitive primate form, evidence of the major evolutionary changes leading to man is practically complete and presents an almost unbroken sequence. The progress can be clearly traced by dental evidence and by the stages of foot development and correlated changes in other parts of the body frame. Both lines of evidence, dental and osteological, support each other throughout.

The gibbon establishes a very apparent connection of the great ape group with the ancient Old World monkey stock by reason of its many simian characters.

The distinctive modifications of the human foot may seem to form a large gap in the sequence of changes when compared with the arboreal great ape foot, but while the human modifications are elaborate and seemingly complex, their complexity vanishes readily under a mechanical analysis which is greatly aided by the terrestrial changes observed in the feet of the gorilla.

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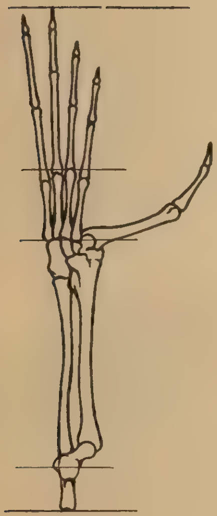


Fig. III

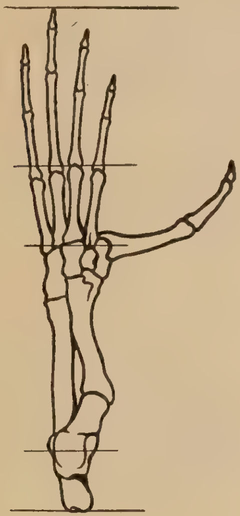
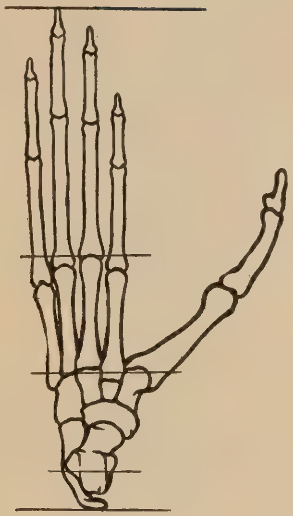


Fig. IV



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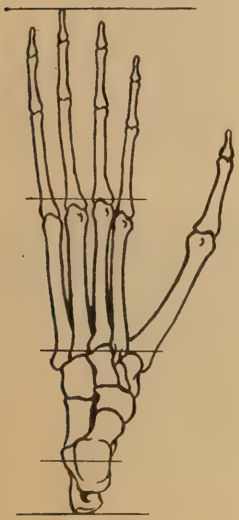

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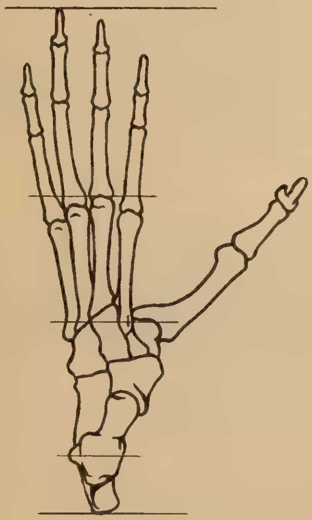


Fig. VII

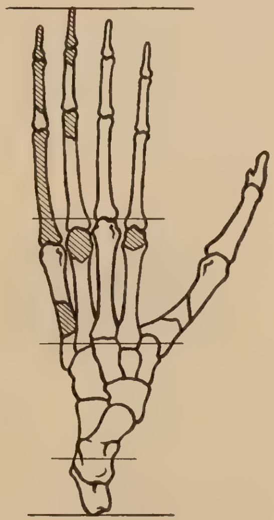
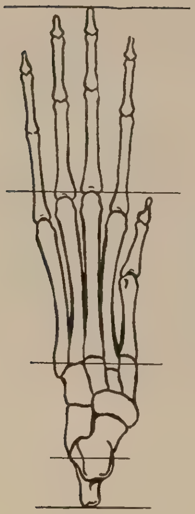


Fig. VIII

Fig. III. Tarsius
Fig IV. Galago
Fig. V. Loris
Fig. VI. Lemur
Fig. VII Lepidolemur
Fig. VIII Notharctus (restored).



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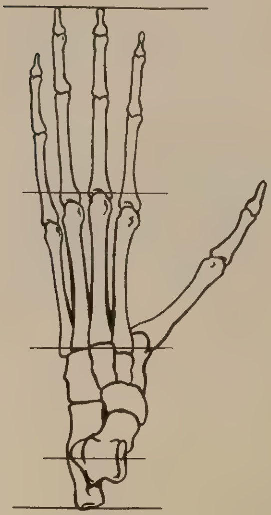

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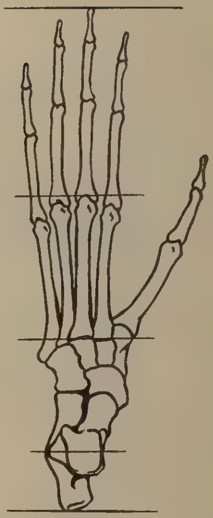

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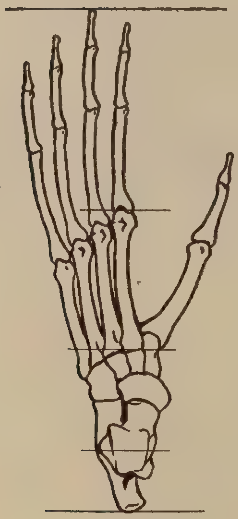

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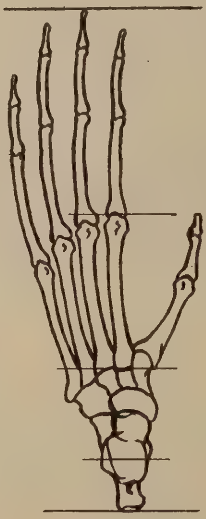

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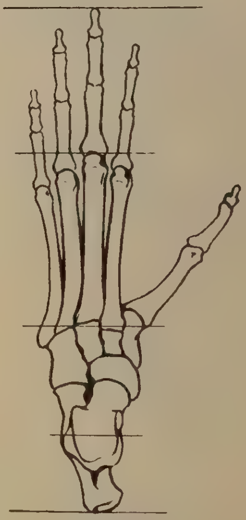


Fig. XIV

Fig. IX Marmoset
Fig. X Callithrix
Fig. XI Cebus
Fig. XII Lagothrix
Fig. XIII Ateles
Fig. XIV Erythrocebus

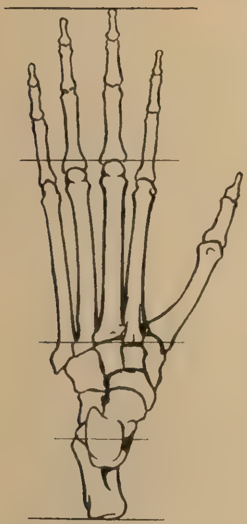


Fig. XV

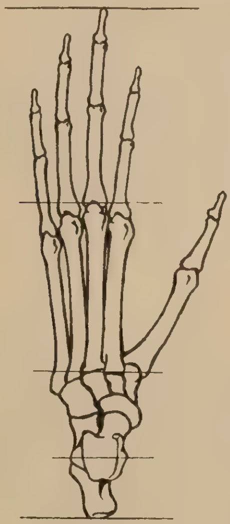


Fig. XVI

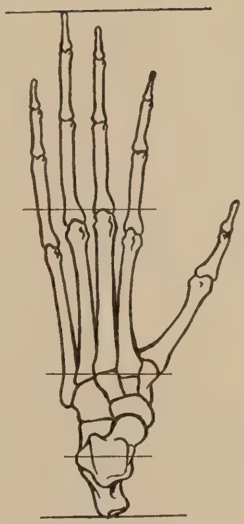


Fig. XVII

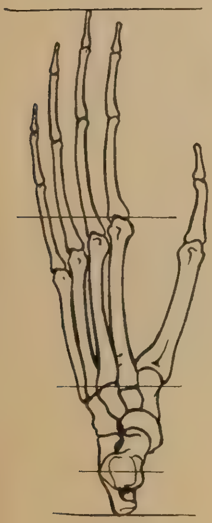
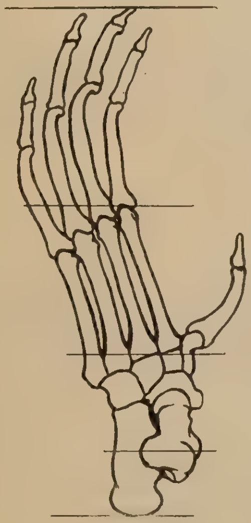


Fig. XVIII



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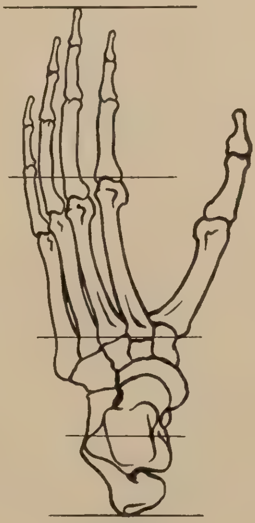


Fig. XX

Fig. XV Baboon
Fig. XVI Macaque
Fig. XVII Langur
Fig. XVIII Gibbon

Fig. XIX Orang (Note relative position of astragalus and os calcis in orang foot as compared to all others, also the increased stoutness of the 4th and 5th metatarsals over that of the 2nd and 3rd, and the atrophy of the hallux. These characters are definitely associated with the structural supinated posture of this foot.)

Fig. XX Chimpanzee.

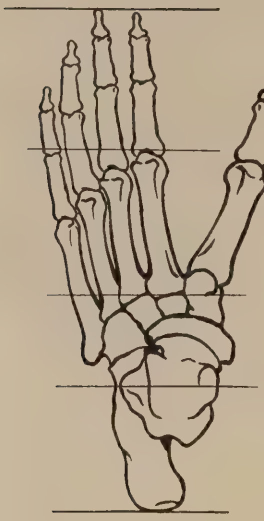


FIG. XXI

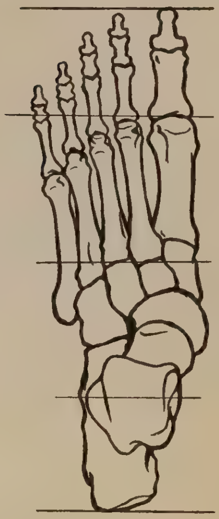


FIG. XXII

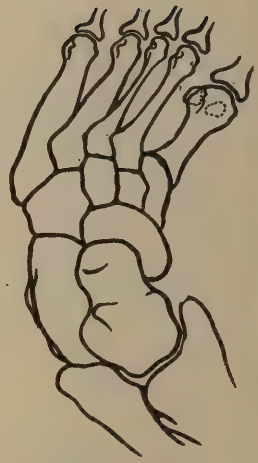
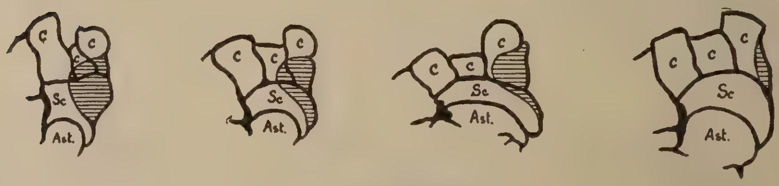
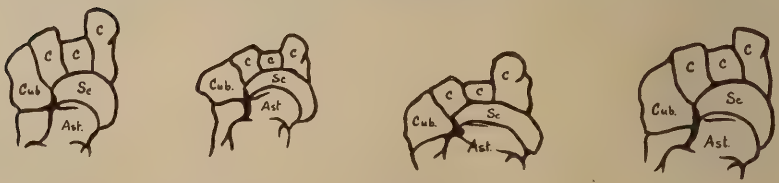


FIG. XXIII



A B FIG. XXIV C D



A B FIG. XXV C D

FIG. XXI Gorilla. (Note the increased stoutness of the 1st and 2nd metatarsal bones as compared to other types of feet, and the equally extended position of their heads, also the marked lengthening of the heel.)

FIG. XXII Homo

FIG. XXIII Talipes equino-varus (club foot), Young Adult. (Note the excessive hypertrophy of the 5th and 4th metatarsals, and the lack of development of the 1st, and 2nd and 3rd. The outer border has been the only functioning part of this congenitally supinated human foot.)

FIG. XXIV Scapho-cuneiform Fossa (Indicated by shaded area) A, Lemur. B, Macaque. C, Gorilla. D, Homo.

FIG. XXV The Mid-tarsal Pattern. A, Gibbon. B, Chimpanzee. C, Gorilla. D, Homo. ccc, Cuneiform bones. Cub, Cuboid. Sc, Scaphoid, Ast, Astragalus. The antero-posterior shortening of the mid-tarsal bones is very apparent in the chimpanzee and gorilla, while man retains a pattern much closer to the gibbon's.

AGE ORDER OF EPIPHYSEAL UNION IN MAN[1]

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INTRODUCTION

The phenomenon of diaphyso-epiphyseal union has long occupied a position of dominating importance in the consideration of gross skeletal metamorphosis associated with the question of age. The time and sequence of union between the various epiphyses and their respective diaphyses has not only been the chief, but in many cases the only, guide of anatomists, archeologists, medico-legal experts, and others in their efforts to estimate the ages of individuals upon the basis of skeletal findings. In spite of the fact that complete union of all the epiphyses in early life naturally restricts the application of this particular type of osteological evidence to skeletons of adolescent or young adult individuals, leaving the determination of age in later life periods dependent upon more generalized though not less definite observations (Todd, '20), still the time and sequence of epiphyseal union will always constitute a prominent factor in age determination within the natural limits just mentioned.

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[1] This article is the substance of a thesis which was accepted for the degree of M.A. in Medicine, Western Reserve University, June 1923.

AM. J. PHYS. ANTHROP., 1924, Vol. VII., No. 1.

TABLE 1. Ages assigned by various authorities for union of epiphyses.

Authority Epiphyses	Bryce ('11)	Dixon ('12)	Dwight ('11)	Gegenbaur ('92)	Henle ('71)	rause (09)	Lewis ('18)	Poirier ('11)	Terry ('21)	Testut ('21)	Thompson ('21)	Earliest	Latest	Difference
Humerus:														
Head	20-22	20-25	20	--	--	22	20	20-25	20	20-25	25	20	25	5 yrs.
Distal Ext.	17	17	15	18	15	16-17	17	16-17	17	16-18	16-17	15	18	3 "
Med. Epicond.	18	18	--	--	16	18	18	16-17	17	17-19	18-19	16	19	3 "
Radius:														
Proximal	17-19	18	16	17	16	16-17	17-18	16-19	17	16-20	18-20	16	20	4 "
Distal	18-20	21-25	19-20	20	19-20	20-21	20	20-25	20	20-25	20-25	18	25	7 "
Ulna:														
Proximal	17-19	17	16	17	15-16	16-17	16	20-21	16-17	16-20	16	15	21	6 "
Distal	18-20	20	18	20	20	20-21	20	22-24	18-20	20-25	20-23	18	25	7 "
Femur:														
Head	18-19	18-20	18	20-25	20	17-19	-Puberty to 20-	18-22	19	18	18-20	18	25	7 "
Lsr. Trochant.	18	18	19	20-25	--	17-19		18-22	17	18	18	17	25	8 "
Gtr. Trochant.	17	18	19	20-25	--	17-19		18-22	18	16-18	18-19	17	25	8 "
Distal Ext.	20	23-24	20	23	--	19-20		22-24	20	20-22	20-22	19	24	5 "
Tibia:														
Proximal	19-24	21	19-20	--	18-25	19	20	18-24	20-25	18-20	20-24	18	25	7 "
Distal	17-19	17-18	18	--	18-25	17-18	18	16-18	18	16-18	18	17	25	8 "
Fibula:														
Proximal	22-24	22-24	20	--	19-25	19	25	22-25	22	19-22	19	19	25	6 "
Distal	20-22	20	18-19	--	19-25	17-18	20	20-22	20	18-19	19	17	25	8 "
Scapula:														
Coracoid	Puberty	17	14-15	16-18	14-15	16-18	15	20-25	15	14-16	15-17	14	25	11 "
Acromion	22-25	22-25	18-19	--	16-17	19-21	--	20-25	20	17-18	25	16	25	9 "
Inf. Angle	25	22-24	20	--	20	21-22	25	--	25	22-25	20-25	20	25	5 "
Vert. Margin	25	22-24	20	--	21-22	21-22	25	25-28	25	20-24	20-25	20	28	8 "
Innominate:														
Primary Elements	Puberty	17-18	15	Puberty	Puberty	16-18	Puberty	15-20	18-20	15-16	16	15	20	5 "
Ischial Tuber.	18-25	18-20	20	24	22-24	17-24	20-25	18-20	20	15-20	20-25	15	25	10 "
Iliac Crest	18-25	18-20	20	24	22-24	17-24	20-25	20-25	20	24-25	22-25	17	25	8 "
Ramal Epiphysis	--	--	--	--	--	--	--	--	--	--	--			
Clavicle	25	25	18	--	18	20-22	25	25	25	22-25	25	18	25	7 "

Without entering into a detailed resumé of the existing views on the subject, it is enough to note that our present conceptions of the time and sequence of epiphyseal union are apparently based almost entirely upon a few chance and wholly uncorrelated observations. A tabulated analysis of the data presented in the current text books of Anatomy (Table 1) for instance, reveals a most striking divergency of opinion as to the actual time of union of the various epiphyses. In this connection, Elliot Smith ('12), when confronted with the task of assigning ages to some of the Royal Mummies of Ancient Egypt, made a similar survey of the existing knowledge on the subject and concluded that "in the present state of our knowledge, it would be rash and altogether unjustifiable to give in figures the precise age of a skeleton without making the reservation that it might be several years older or younger than the estimate." Similar difficulties were apparently met with, though less clearly stated, by F. Wood Jones ('10) in his study of the age and sex of a large number of human remains from lower Nubia.

The extent to which the venerable hand of tradition still controls our teaching on the subject of the time element in epiphyseal union is seen in the frequency with which expressions found in the earliest editions of well known texts are retained practically verbatim in some of the latest editions of these same works. Very rarely indeed do we find a reviser of a text book taking exception to archaic ideas of a former day and inserting, as in the case of Dwight ('11), contrary though positive evidence based upon his own scanty observations. In the more recent anatomical literature outside of text books the writer also fails to find any reference to an adequate studyof the exact ages at which the various epiphyses unite. In fact, the present practice of anatomical text books of dealing with the subject in only the most general terms certainly leaves the enquirer with the impression that epiphyseal behavior is so erratic in nature as to defy its reduction to formula.

In view of the obvious deficiency of our present knowledge along this line, and the attending difficulties even in the hands of the most competent in the way of applying the present confusing data to the actual determination of age of historical or otherwise valuable skeletal material, it seems highly desirable to review our knowledge of the age and sequence of union of the various epiphyses and to establish, if possible, a more authoritative basis for the determination of age by reference to epiphyseal union than has hitherto been done.

The present communication results from an effort to revise our knowledge of the time and sequence of epiphyseal union. The facts herewith presented are derived from a detailed study of actually uniting epiphyses in a series of skeletons of definitely known age. This age-known material arranges itself with sufficient evenness throughout the whole period of epiphyseal activity to make possible an accurate determination of (1) the age of the union of the individual epiphyses (2) the sequence of union of the different epiphyses, and (3) the actual duration of the period of epiphyseal union as a whole.

Many interesting questions of varying importance naturally arise during an investigation of this kind. Most of these, largely because of their rather speculative nature, are rigidly excluded from this paper in which the writer purposes to confine himself almost exclusively to facts bearing directly upon the time and sequence of epiphyseal union in the human body. Certain impressions concerning the fundamental nature of the phenomenon of epiphyseal union in general and the alleged relationship between epiphyseal union and growth in particular, however, seem inevitable from the evidence at hand and will be touched upon in appropriate sections. Bare mention of observations on the behavior of epiphyses in primate forms other than Man must be made in the discussion first of the sequence of epiphyseal union, and secondly in dealing with the fundamental nature of the phenomenon of epiphyseal union.

The constancy of the age factors involved, not only in the process of epiphsyeal union as a whole but in the union of the large majority of individual epiphyses as well, will be repeatedly emphasized throughout this paper. Although, for the sake of completeness, the more erratic epiphyses of the scapula and os innominatum will also be described, yet the behavior of these is clearly the exception to the general rule and the reader is warned against allowing their relatively variable behavior to detract his attention from the main premise of constancy and regularity, as demonstrated in the case of all the more important epiphyses of the body.

As a further word of introduction it is to be mentioned that this study represents an integral part of a series of studies on age changes in the skeleton being carried on in the anatomical laboratory of Western Reserve University. Such matters as the general scope of these interesting studies, as well as the questions of age records, uniform routine preparation of skeletal material with the particular end of age studies in view, and other pertinent subjects are treated somewhat in detail in Professor Todd's initial publication on the subject (*op. cit.* pp 285–292), and apply equally well to the material used in the present study on the epiphyses.

MATERIAL

The authority of a study such as this depends largely upon three factors; (1) the *number* of complete skeletons of suitable age period available, (2) the undoubted *normality* of the material used, and (3) the question as to whether or not definite *data as to the age* of the skeletons is available.

Of the approximately 1,000 complete skeletons now filed in the Western Reserve collection, 128 fulfilled the first of the above mentioned conditions, being within the age period between 15 and 28 years. Of this number failure on the part of 18 to conform to the required conditions regarding unquestioned normality and definite age data reduced the number to 110. The one exception to this rigid rejection of skeletons for which it was not possible to produce unimpeachable evidence as to age is the one in the fifteen year column (of the table below) about which there is conflicting evidence as to whether the correct age is fourteen or fifteen years. This body is included solely because of the very valuable evidence which it presents concerning the *sequence* of epiphyseal union.

TABLE 2. Number, stock, sex, and age of skeletons used in this study.

		Period I					Period II									Totals
Stock	Age	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
White	M.				2	2	3	2	4	4	4	5	4	7	2	39
	F.				2	1	1			1		3		1	1	10 (49)
Colored	M.			1	5	3	5	4	9	7	4	1	4	3	5	51
	F.	1		2	1		2				2	2				10 (61)
Totals		1		3	10	6	11	6	13	12	10	11	8	11	8	110

On account of the existing uncertainty as to its exact age it does not appear either in the argument or graphs dealing with the *time* of epiphyseal union. Table 2 shows how this total number is divided as to human stock, sex, and age. The number of Whites and Negroes is practically the same, while the males greatly predominate in both races. The heavy vertical line divides the total age period into two shorter periods. The first of these, up to and including the twentieth year is characterized by the completion of all epiphyseal union in the so called long bones (v. also Fig. 11 and Plate I), and will be considered the true epiphyseal period; while the second period, from the twenty-first to the twenty-eighth years, witnesses the more delayed union of certain other constantly present epiphyses, notably those of the scapula, os innominatum, and clavicle.

Although this study is primarily concerned with the time and sequence of epiphyseal union in the case of the human body, yet studies on a larger number of other mammalian forms to be published later show that the *sequence* of union is apparently constant throughout the entire range of land mammals. Where a rather critical gap in the definitely age-known human material in the earliest stage of epiphyseal activity made the procedure necessary three skeletons of higher Primates other than Man were selected to show intermediary stages. Use of this material was made only after it had been clearly demonstrated to the writer that in sequence of epiphyseal union anthropoid material is absolutely identical with the human. As in the case of the 14-15 year specimen mentioned above, this outside material is concerned only in the case of the *sequence* of union, and will not enter into the discussion of the time of epiphyseal union.

STAGES AND CRITERIA OF UNION

Before beginning a specific investigation of the time and order of union of the various epiphyses, a preliminary study of the phenomenon as a whole was made in order to acquire a general appreciation of the progressive changes taking place at the epiphyso-diaphyseal junction. Through such a study it is possible to recognize four more or less distinct phases of epiphyseal union, each presenting characteristic and constant features. (1) In the first, or stage of *no union*, the clearly evident hiatus between the epiphysis and diaphysis, as well as the characteristic saw-tooth-like external margins of the approximated diaphyseal and epiphyseal surfaces, present unmistakable evidence of the condition of nonunion. In this stage the epiphysis has not infrequently become entirely separated from the diaphysis in the process of maceration, leaving a billowy surface which is characteristic of this stage; a point to be noted in connection with the less frequent cases of epiphyses becoming forcibly separated at a later stage when partial union has taken place. (2) In the second, or stage of *beginning union*, a tendency is evident for the distinct superficial hiatus between epiphysis and diaphysis to be replaced by a line. The saw-tooth character of the approaching margins is gradually lost through the deposition of finely granular new bone in the depressions. Quite as characteristic of this stage is an occasional bridging over or knitting together of the two margins, an external manifestation of the process of obliteration of the space between the diaphysis and its epiphysis. This process of bridging over and progressive obliteration of the epiphyseal line becomes increasingly conspicuous from this stage on. Diaphyseal and epiphyseal surfaces resulting from the occasional complete separation of the epiphysis at this stage are not difficult to distinguish from those of the preceding stage when the filling in of the depressions by new bone deposition and the resultant smoothing out of the former rugged surface is noted. (3) The third, or stage of *recent* union, is the least definite of the four and offers at times some difficulty even to the most experienced observer. This stage is characterized chiefly by the retention of a fine line of demarcation, although the active process of bony union is plainly over. This line, which varies much in distinctness on different bones and in different skeletons, can be seen best in freshly macerated skeletons, when it usually, though not always, has a faintly reddish color. The line in question must be clearly distinguished from the "epiphyseal scar" which is occasionally met with in the fourth stage, and less frequently throughout life. (4) The fourth, or stage of *complete union*, represents the completion of the process of union and usually offers no difficulties in its recognition. In a certain small percentage of cases there may be a faint epiphyseal line persisting throughout life. Care must be taken in the case of such lines, however, especially in the case of the distal end of the femur and the proimal end of the tibia not to mistake a relatively conspicuous line of capsular attachment for the epiphysial line itself.

Although four distinct stages of epiphyseal union have been noted above, and all four stages will be regularly indicated in the charts and diagrams which follow, still it must not be considered that they represent differences of equal importance. Stages (1) and (2) represent but slightly different phases of an as yet ununited condition, while stages (3) and (4) similarly represent only slightly different phases of total union of an epiphysis. The difference between nonunion and union is distinct and significant, that between the respective minor phases of each is less distinct and less significant. The essential point to note, therefore, in the union of any particular epiphysis as it is being followed through a series of individuals of increasing age, is the change from the first of these major conditions, with its two qualifying phases, to the second major condition, of which two more or less distinct phases are also recognizable. And it is the time at which this significant transition between the major stages of absolute nonunion and complete union respectively takes place that determines the actual age of union of the epiphysis in question.

Having in mind these different stages of epiphyseal union and their relative significance, the behavior through successive age periods of twenty-eight distinct epiphyses of ten bones of the human skeleton will now be briefly described.

AGE OF UNION OF VARIOUS EPIPHYSES

Chronological sequence in any series of bodily changes is most naturally represented in diagramatic form. Although the changes taking place in the various epiphyses of each bone will be briefly described under the respective headings of this section, yet the gist of the present study will most easily be presented in the accompanying graphs, and the most satisfactory conception of the time and sequence of union of the epiphyses in question can best be obtained through a careful study of these diagrams as they appear in the text.

Definite evidence for the date of union of an epiphysis rests upon three principles. The series of skeletons being arranged in age sequence; (1) before a certain age no skeleton shows union of the epiphysis in question; (2) after a certain age every skeleton shows union of that particular epiphysis; (3) between these age limits lies the period during which union is actually taking place.

At this juncture, as an aid in readily utilizing the first two of the above factors in the determination of the third, attention is called to the significance of the dotted line in the figures that follow. This line running horizontally across each diagram, separates an area representing nonunited epiphyses below from one representing united epiphyses above. The slight fluctuations within these two areas indicate the qualifying phases (v. supra) of nonunion and union respectively and are of secondary importance only. The important point to notice is the particular age period during which the graph of the uniting epiphysis crosses the dotted line from below upward. This is the period during which union is actually taking place.

HUMERUS

(*Fig. 1.*)

In the humerus a relatively late fusion of several separate centers of ossification results in the appearance of three well defined and constant epiphyses; those of the distal extremity, medial epicondyle, and head. Of these three epiphyses, two show indications of very early union, in

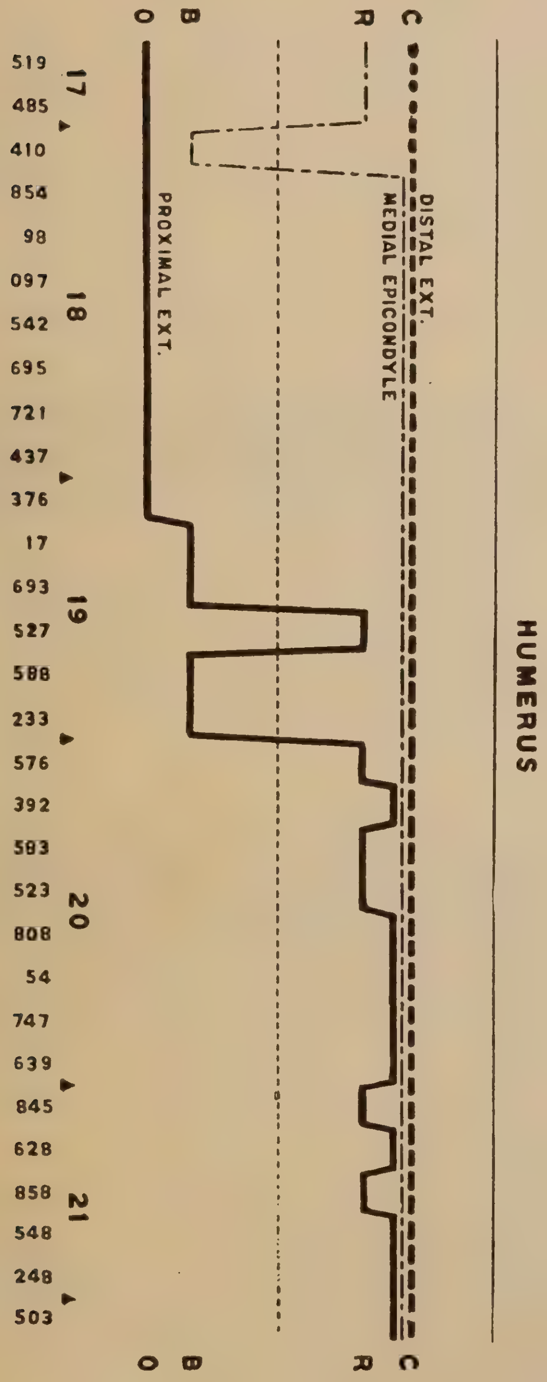

FIG. 1. Age of union of epiphyses of humerus.

fact before the seventeen year age period at which the present series of age-known material begins. Evidence as to the time of union of the epiphysis of the distal extremity, however, is to be found in skeleton No. 633 (the fourteen-fifteen year old skeleton which is not included in the age-known series for reasons assigned above). In it, as shown in Plate II, the distal epiphysis is already completely united. For the present therefore one must tentatively assign the union of this epiphysis at the distal extremity of the humerus at fourteen to fifteen years. Of the epiphyses included in the present study this is the earliest to unite, and it will receive later treatment in the discussion of the sequence of epiphyseal union.

The actual age of union of the medial epicondyle is also earlier than seventeen years. Complete absence of union of the epiphysis in the case of skeleton No. 633, however, places the event after the fourteen-fifteen year period, while the recent union in the case of the seventeen year old skeletons indicates that union takes place at about sixteen years.

For the head of the humerus, as for practically all the remaining epiphyses of the body, we are able to assign definite limits to the date of union. No skeleton under nineteen years shows even commencing union of the humeral head. After the age of nineteen, on the other hand, this epiphysis is already united in every skeleton. It follows that the nineteenth year is the period during which actual union of this particular epiphysis takes place. Or, stating the matter in a slightly different way, union of the head of the humerus indicates that the individual under observation is twenty or more years old. The head of the humerus, it may be mentioned here, is the last to unite of the epiphyses under consideration, and we will have occasion to refer to it again in the discussion of the sequence of epiphyseal union.

In summary, the ages at which the various epiphyses of the humerus will be found united are; the distal extremity at fifteen years (tentative), the medial epicondyle at sixteen years (tentative), and the head at twenty years.

RADIUS AND ULNA

(*Figs. 2 & 3.*)

The epiphyses of the radius and ulna may be conveniently treated together. It is evident that the proximal epiphyses of both these bones unite considerably earlier than those of their distal extremities. The proximal scalelike epiphysis capping the olecranon process of the ulna represents what may be termed an extra-articular epiphysis, a

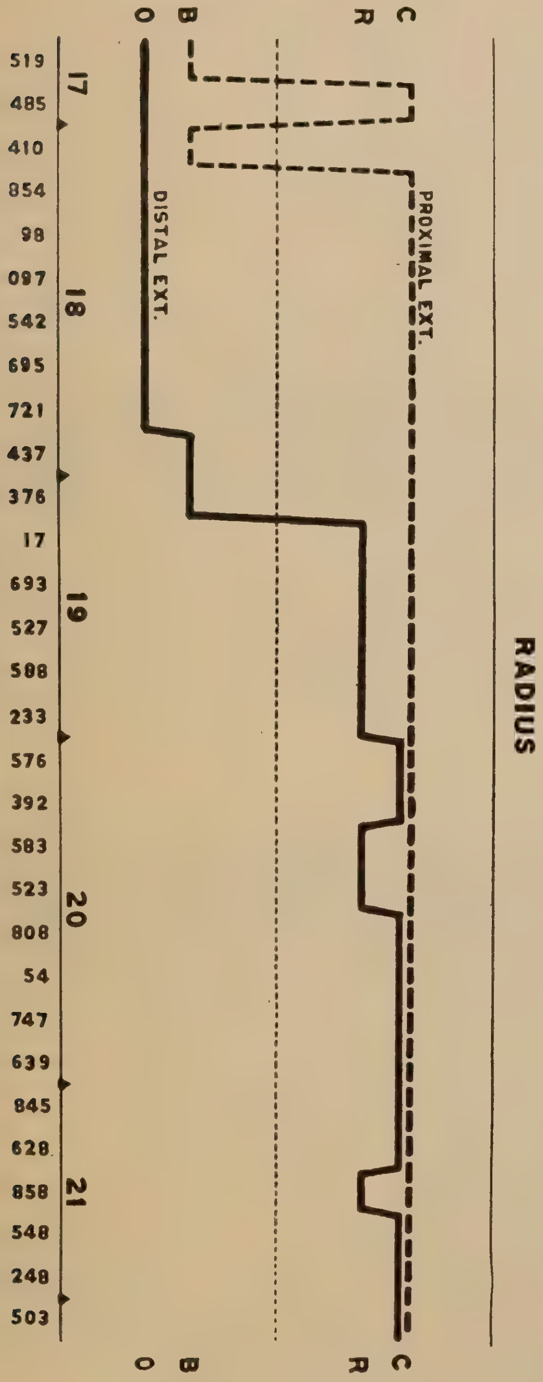

FIG. 2. Age of union of epiphyses of radius.

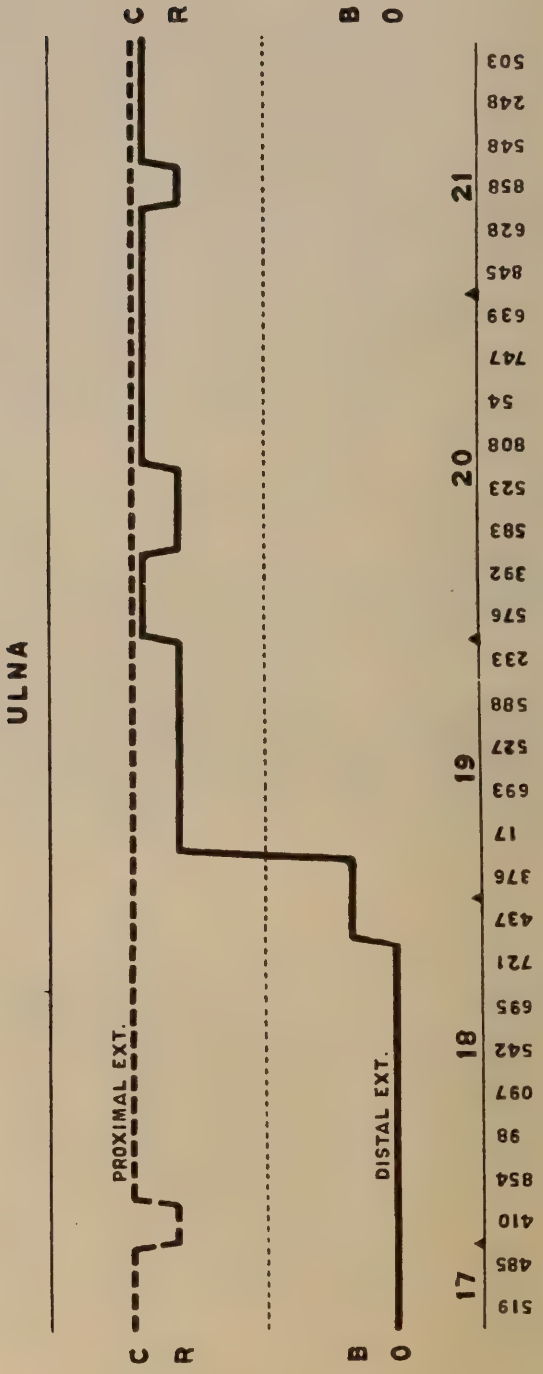

FIG. 3.—Age of union of epiphyses of ulna.

type which, as will be shown subsequently, is less constant in behavior and hence less valuable as an age indicator than the ordinary epiphysis entering into joint formations. Union of the proximal ulnar epiphysis occurs somewhat earlier than the seventeenth year, probably at about the sixteenth, and the actual time of this union, on the same grounds as in the case of the medial epicondyle of the humerus cited above, must be tentatively stated as sixteen-seventeen years.

The head of the radius, more constant in its behavior than the proximal epiphysis of the ulna just described, does not show consistent union before the beginning of the eighteen-year period. Without exception, on the other hand, this epiphysis is firmly united in all cases over eighteen years of age. It may be stated therefore, that the eighteenth year is the period of union of the epiphysis of the head of the radius.

The close parallelism in the behavior of the distal epiphyses of the radius and ulna is noteworthy. The graphs of these indicate that union with their respective diaphyses takes place in the early part of the nineteenth year.

The ages at which the epiphyses of the radius and ulna unite are the following: sixteen-seventeen years for the proximal epiphysis of the ulna, eighteen years for the head of the radius, and nineteen years for the distal extremities of both bones.

FEMUR

(*Fig. 4.*)

The epiphyses of the femur comprise the lesser and greater trochanters, the head and the distal extremity. All of these are remarkably constant in date of union and are accordingly useful indicators of age. Contrary to what one would expect from conventional statements, the two trochanters and the head unite practically simultaneously, although the lesser trochanter exhibits a tendency to unite slightly earlier than the other two proximal epiphyses of this bone. The time of union of all the proximal femoral epiphyses is the early part of the eighteenth year.

The evidence is equally clear that union of the distal epiphysis of the femur takes place approximately a year later, namely, in the early part of the nineteenth year. The accelerated union of this one epiphysis in the case of skeleton No. 721 is an extreme example of individual variation in the case of a single epiphysis of the body, for with this one exception all the remaining epiphyses of this particular skeleton are found to conform to the usual eighteen-year type.

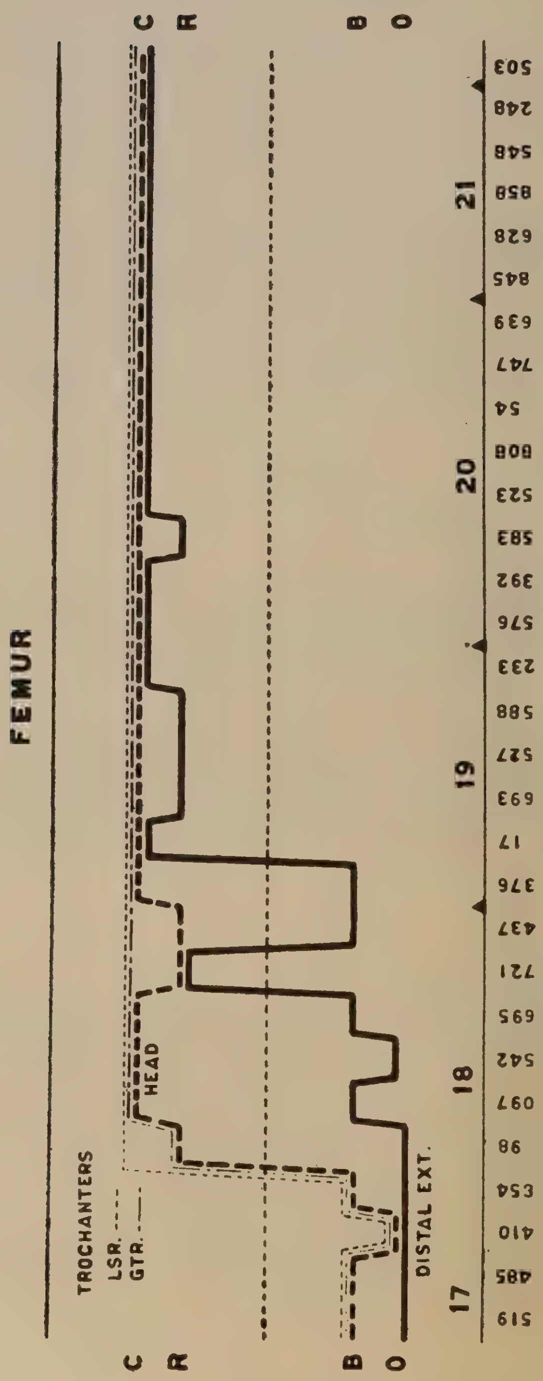

FIG. 4. Age of union of epiphyses of femur.

For the epiphyses of the femur, therefore, the age of eighteen years is the time of union for the two trochanters and the head, while nineteen years is the age of union of the distal extremity.

TIBIA AND FIBULA

(*Figs. 5 & 6.*)

The epiphyses of the tibia and fibula, like those of the radius and ulna, may conveniently be considered together. Contrasted with the definite behavior of the radial and ulnar epiphyses, however, these four epiphyses of the tibia and fibula show a relatively large degree of individual variation, and are on the whole the least reliable as age indicators of all the long bone epiphyses.

The distal epiphyses are more constant than those of the proximal ends of the bones in the date of their union. Although there is evidence in some skeletons (v. No. 98) that the distal epiphysis of the tibia may unite a little before that of the fibula, yet the eighteenth year is clearly the period during which both these epiphyses unite.

The proximal epiphyses, especially in the fibula, show a considerable degree of individual variation. No skeleton exhibits union of either of these before the early part of the eighteenth year, and it is not until practically a year later that union is complete in every skeleton in the series. Although this period of fluctuation is not of considerable duration, and is certainly much shorter than that usually ascribed to even the most constant epiphyses, still it is relatively long when compared with the more definite behavior that characterizes the other long bone epiphyses already described.

With the exception of the tibial and fibular epiphyses, particularly that of the proximal end of the fibula, the long bone epiphyses described in the preceding paragraphs of this section are distinguished by a characteristic constancy of behavior which makes them of primary importance in age determination. There follows a group of bones—the scapula, os innominatum, ribs, and clavicle—most of the epiphyses of which are of the marginal type, some of them probably vestigial in nature (v. infra), and all of them rather variable in date of union. As indicators of age, therefore, they are to be considered distinctly secondary in importance to the epiphyses of the long bones.

Certain skeletal elements which strictly cannot be called epiphyses are also associated with these bones. These—the coracoid and acromion of the scapula, and the three primary elements of the innominate bone in particular—exhibit such constancy in their dates of union, and as a

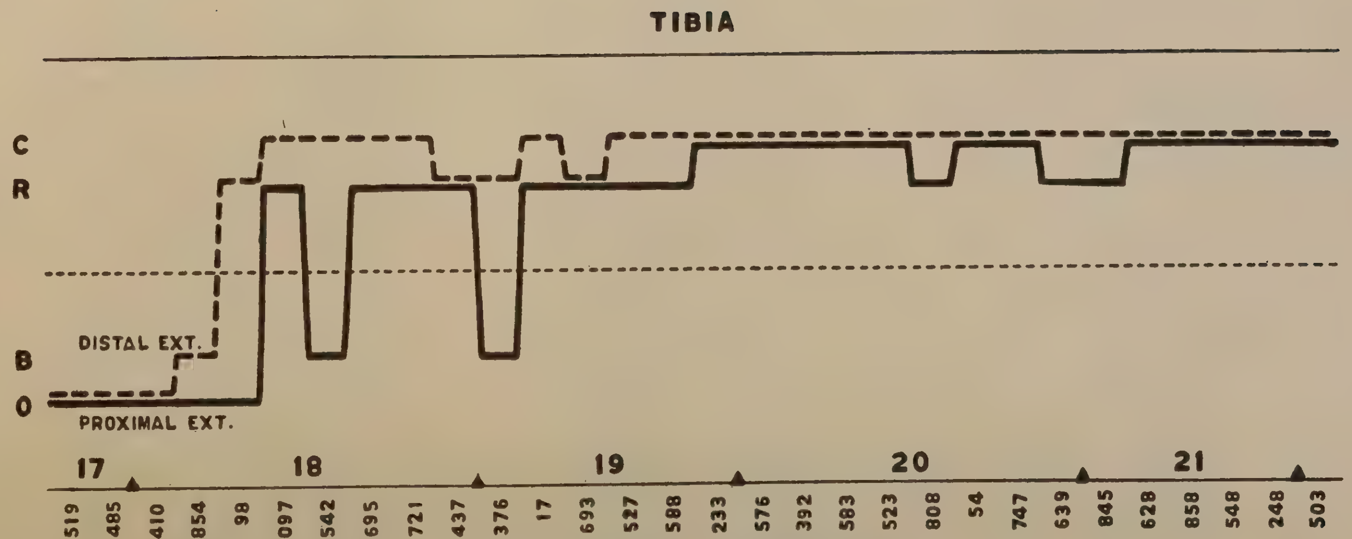

FIG. 5. Age of union of epiphyses of tibia.

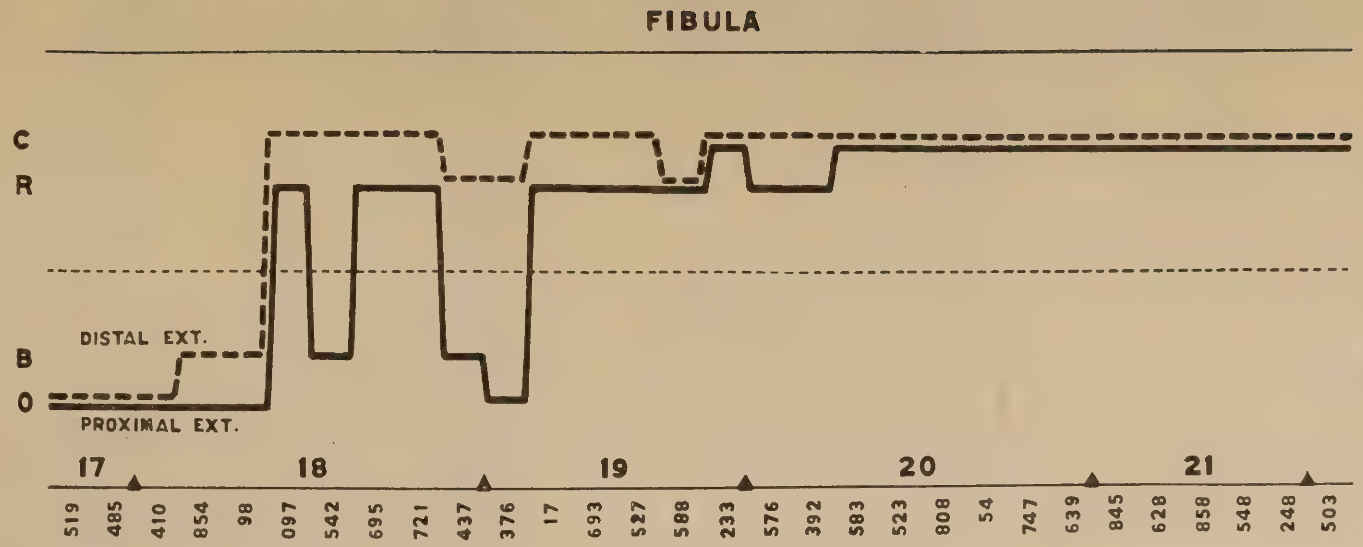

FIG. 6. Age of union of epiphyses of fibula.

result have such definite value as indicators of age that their inclusion in this study is rendered imperative.

SCAPULA

(*Fig. 7.*)

Union of the coracoid with the body of the scapula takes place relatively early in the age scale of epiphyseal union. The evidence (Plate II) shows, in fact, that this process unites very soon after the epiphysis of the distal extremity of the humerus, and not later than the fifteenth year. The constancy in date of union of the coracoid makes it of particular value as an indicator of age.

The acromion not infrequently fails entirely to unite with the scapula. This study shows that when union of the acromion does occur, however, it takes place quite constantly in the nineteenth year. As an age indicator it must be remembered that the acromion is of value only in case it has united.[2]

There remain two so-called marginal epiphyses, occurring at the inferior angle and the vertebral margin of the scapula respectively. These epiphyses behave as two distinct entities in Man as in other primate forms, whatever their true morphological significance may be in other mammalian types. The vestigial character of these marginal epiphyses probably accounts for the relatively great individual variation in the date of their union, a fact which renders them particularly unreliable as indicators of age. The date of union for these varies in different individuals between the nineteenth and twenty-second years.

OS INNOMINATUM

(*Fig. 8.*)

The date of union of the three primary elements, ilium, pubis and ischium, is very constant and constitutes a reliable check, once its proper sequence is understood (v. infra), on other age indicators of the body. A degree of caution must be observed, however, when attempting to determine the stage of union between these three bony elements as the process varies somewhat in different regions, and in the acetabulum in particular is not infrequently complicated by the inconstant triradiate cartilage found in the bottom of this fossa. To eliminate this source of possible error, therefore, all observations included in this study were made on the inside or pelvic surface of the innominate bone, where the lines of union are clear-cut and the condition of union or nonunion

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[2] The condition known as separate acromion is not an ununited epiphysis but an anomalous formation of the acromion. This is not the place for an adequate discussion of the anomaly; hence Doctor Stevenson's careful reservation (T. W. T.).

SCAPULA

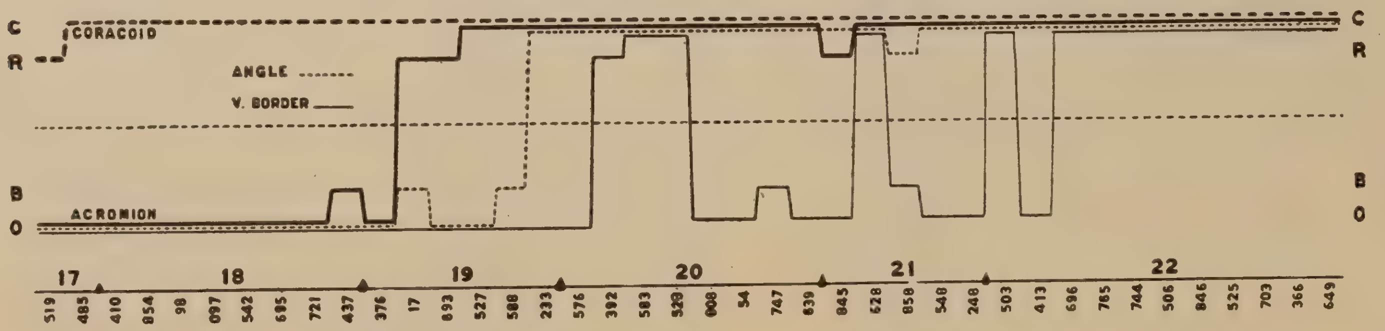

FIG. 7. Age of union of skeletal elements and epiphyses of scapula.

INNOMINATE

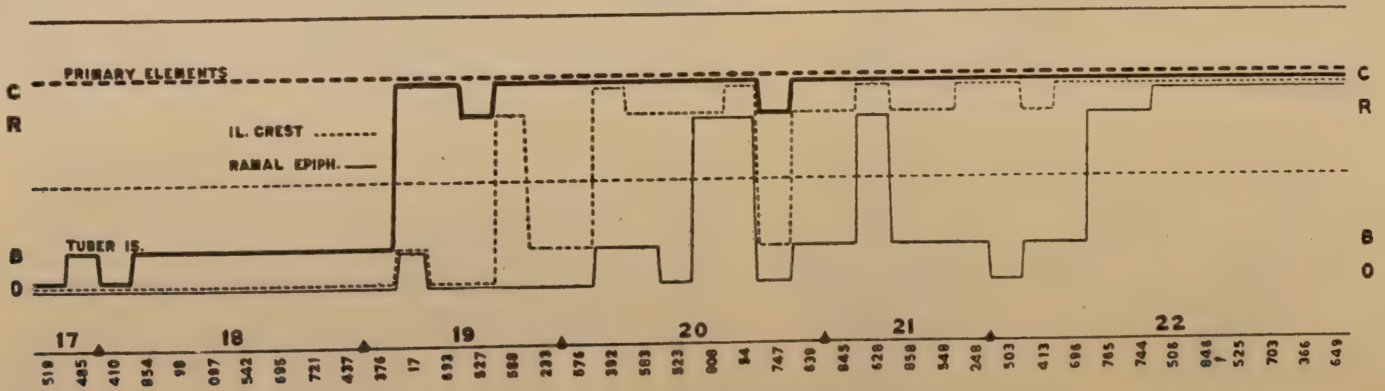

FIG. 8. Age of union of skeletal elements and epiphyses of os innominatum.

definitely determinable. The actual date of union of the three primary coxal elements can only tentatively be stated at this time. From the present study it is evident that it takes place definitely later than union of the distal extremity of the humerus, and is to be assigned (tentatively) to the fifteen-sixteen year period (Plate II).

The epiphysis capping the tuberosity of the ischium begins to unite on the posterior aspect of the tuberosity at the beginning of the eighteenth year. Union only gradually, though quite regularly, extends anteriorly, and is found to be complete from the nineteenth year onward. The constancy of these two phases of union of this epiphysis justifies its inclusion among the valuable age indicators of the body.

There remain two marginal epiphyses of the innominate bone to be considered. The one surmounts the entire crest of the ilium, and results from a rather late union of separate anterior and posterior ossification centers, while the other is a small slip extending ventrally and medially from the tuberosity of the ischium along the inferior border of the joined ischio-pubic ramus. This latter epiphysis is spoken of as the "ramal" epiphysis. The extreme degree of variability found in both iliac crest and ramal epiphyses may be attributed in part at least to the composite nature of the former, and to the vestigial character of the latter. The ramal epiphysis in the human body represents the remnant of a considerably larger element extending the entire length of the ischio-pubic ramus and participating in the formation of the symphysis pubis (v. Todd, '21) in some of the other primate forms. The epiphysis of the iliac crest unites between the nineteenth and twenty-first years, while the ramal epiphysis begins to unite also in the nineteenth year but does not complete its union until the twenty-second year.[3]

In spite of the variability in date of union of these two epiphyses attention might be well called at this point to the fact that the pelvis as a whole records age changes more accurately and over a longer period of time than any other skeletal element in the entire body. At the time that the skull ceases to be a reliable guide to age, namely at the end of the change from deciduous to permanent dentition, the coxal bone first comes into prominence as an indicator of age. Union of its three primary elements occurs at the age of fifteen years. Following this there is a period of activity on the part of its epiphyses extending through the twenty-second year, from which time the symphisis pubis becomes an increasingly reliable guide through the thirty-forty year period (Todd, '20, '21, '23), at which time the characteristic lipping of muscle attachments regularly occurs. This period is followed by another only slightly less definite series of secondary changes resulting from the onset of senile absorptive processes which become manifest in the forty-fifty year period. Hence the innominate bone proves a valuable indicator of age throughout a considerable portion of the entire life span.

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[3] This is a valid method of stating the date of union of the 'ramal' epiphysis for it must be remembered that the ramal epiphysis includes more than the vestigial ossifications on the symphysial face. (T. W. T.).

RIBS

(*Fig. 9.*)

The small scale like epiphyses of the ribs, especially those of the tubercles, present certain difficulties of interpretation of the variable conditions found. The epiphysis for the tubercle, for instance, unites as it ossifies, so that a completely ossified though ununited epiphysis on this process is very rarely seen. The denuded surface of the tubercle, moreover, in cases where the cartilaginous epiphysis is removed during maceration, instead of presenting the rugged appearance typical of a diaphyseal surface exposed though the loss of an epiphysis, is quite smooth and simulates with remarkable closeness the appearance of the united epiphysis itself. Careful study of these particular epiphyses, however, reveals the fact that they unite in most cases in the eighteenth year.

The epiphyses of the heads of the ribs present in a lesser degree the same difficulties as those of the tubercles. After practically two years of fluctuation they are found to be united in all cases after the twenty-second year. The epiphyses of the ribs, in sharp contrast with those of the long bones of the body, are of very little value as indicators of age.

CLAVICLE

(*Fig. 10.*)

The epiphysis at the sternal end of the clavicle has long been considered unique, not only on account of its being the only clearly recognized epiphysis of the clavicle but also because of its delayed union. In addition, this small cartilaginous disc belongs to a type of articular epiphysis often associated with amphiarthroses—symphysis pubis, intercentral joints of the vertebral column, and manubrio-gladiolar articulation of the sternum, for instance—the adjacent epiphyses of which ossify erratically, incompletely, or not at all. It is not surprising, therefore, that this epiphysis exhibits the longest range of activity as

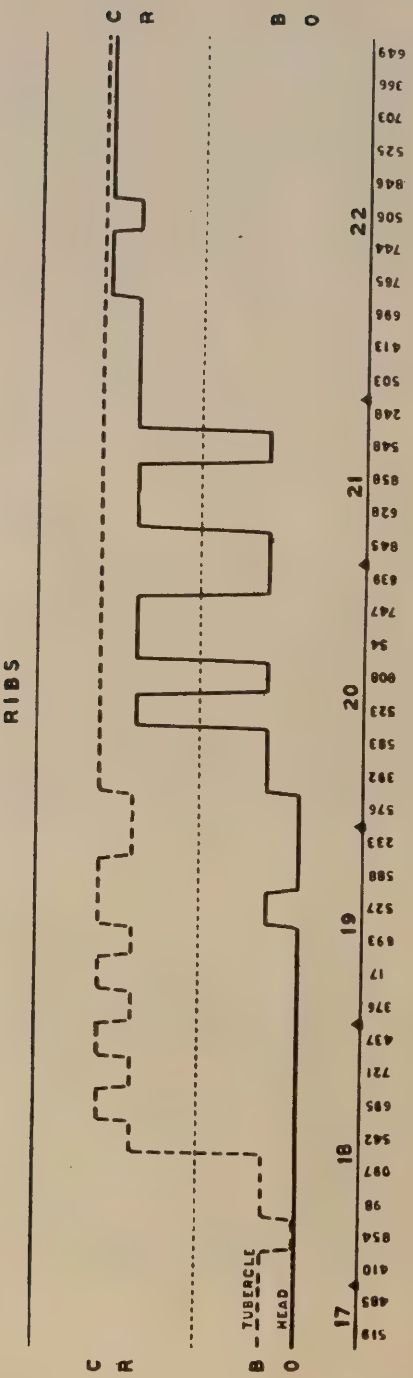

FIG. 9. Age of union of epiphyses of ribs.

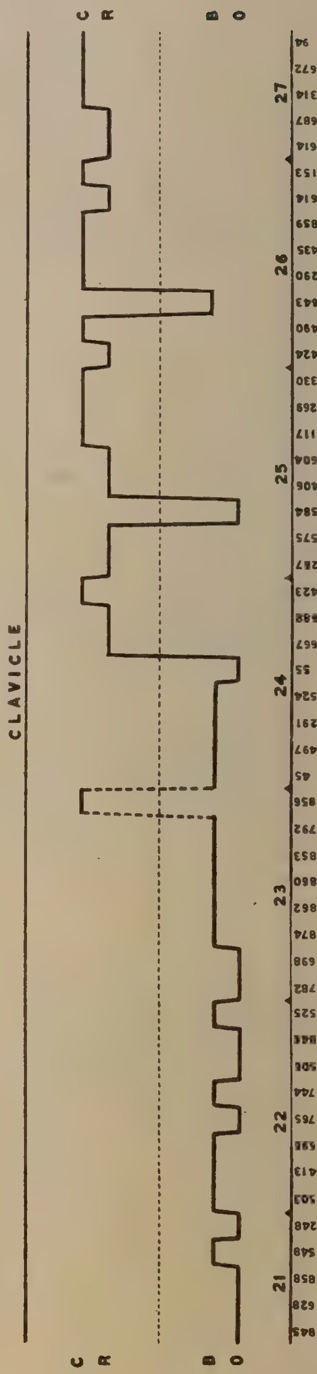

FIG. 10. Age of union of sternal epiphysis of clavicle.

well as the most extensive range of individual variation of any of the epiphyses so far studied. The epiphysis in question shows evidence of beginning union in several of the twenty-two year skeletons, and of having only recently united in several of the twenty-seven year individuals. In fact, it is not until the twenty-eight year old group is reached that this epiphysis is found to be united in all the cases. The usual impression that this epiphysis unites more or less constantly at the twenty-fifth year, and the common practice of considering skeletons to be either older or younger than twenty-five according to whether the sternal epiphysis of the clavicle is united or ununited, seems entirely unwarranted. It is impossible to assign any age at which this epiphysis will certainly be completely united below the twenty-eighth year.

The reader may have wondered that no distinction has been made between the time of union in the different races or sexes in the foregoing survey of the ages at which the various epiphyses unite. Although the material was so arranged and the records so made that such differences might be easily detected and recorded, none presented itself. This finding is at variance with the accepted impression of epiphyseal activity (v. Testut, Poirier, and others).[4] Owing to the relatively small number of cases it is not pretended that the evidence on this point is conclusive. It is very probable, however, that such differences if they exist are very slight, and will be found to resemble in kind and degree the racial and sexual differences in age of appearance of other bodily metamorphoses such as dentition and secondary sex characteristics.

Analysis of the Age Factor in Epiphyseal Union

Several important facts stand out clearly in an analysis of the data just presented. (1) Epiphyses may be divided into two classes: (*a*) those the time of union of which is sufficiently constant to make them safe and useful indicators of age, e. g. epiphyses of the limb bones in particular, and (*b*) a very much smaller group subject to fluctuation in the age at which they unite and hence of little direct value as age indicators, e. g. marginal epiphyses of scapula and os innominatum and also those of ribs and scapula. (2) *The period of life between fifteen and twenty*

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[4] The recent assertion by Pryor, made without any confirmatory evidence, that epiphyses in the female unite three to four years earlier than in the male (Differences in the time of development of centers of ossification in the male and female skeleton. 1923. Anat. Rec., vol. 25, p. 268). receives no support in this work. On the contrary the reader is warned against relying too confidently upon the apparent condition of union or of non-union in the radiogram which is merely a confusing medley of shadows.

years is pre-eminently the period of epiphyseal union. No important epiphysis of the first group mentioned above unites outside the limits of this period. (3) Not only are the limits of the above period remarkably constant in the case of all normal individuals, but the time of union of each epiphysis is also relatively constant within this period. (4) Within the total period of epiphyseal activity there is a brief period of intensive epiphyseal union during which a much larger number of different epiphyses are uniting than during preceding or succeeding periods. Fig. 11 depicts the curve of epiphyseal activity based upon the proportional number of epiphyses actually uniting during the respective phases of the entire period. Up until the age of eighteen, it will be noted, relatively few epiphyses have begun their process of union. The curve rises sharply in the eighteenth year, reaches its peak in the nineteenth year when the largest number of epiphyses complete their process of union, and then falls off rapidly. The abrupt fall in the curve is arrested in the twentieth and twenty-first years by the subsequent period of union of the marginal epiphyses of the scapula, os innominatum and heads of the ribs, while the prolongation of the curve after this point is due to the long drawn out period of union of the sternal epiphysis of the clavicle.

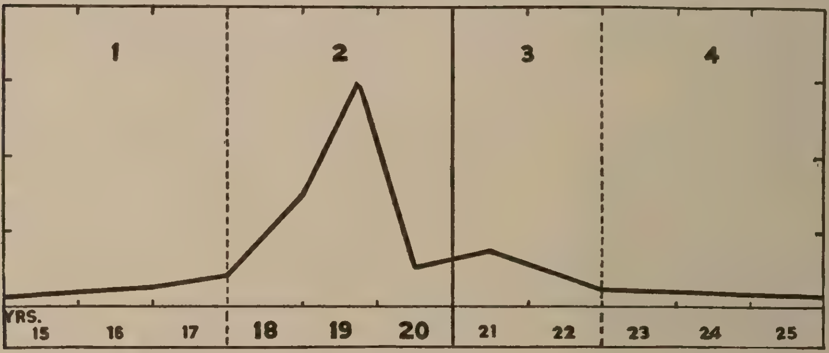

FIG. 11. Curve of relative intensity of epiphyseal activity according to age.

It is of distinct value to emphasize the significance of the fifteen to twenty-year period of life as the real period of epiphyseal union. Upon the basis of such recognition it becomes possible to define three distinct and easily differentiated age periods of adolescent and early adult life, namely, the periods, before, during, and after this fifteen to twenty-year period of epiphyseal union respectively. It becomes also of very practical interest to note that examination of the epiphyses of the humerus alone suffices to orient quickly and accurately any individual with respect to these three life periods. This is due to the fact that the epiphyses of the distal and proximal extremities of the humerus are the first and the last of the constant epiphyses of the body to unite (v. supra p. 62) and themselves define the lower and upper limits respectively of the fifteen to twenty-year period of epiphyseal union. Absence of union of the distal epiphysis of the humerus indicates that the individual is younger than fifteen years; complete closure of the epiphysis of the head of the humerus, on the other hand, is strong evidence that the individual in question is over twenty years of age. Complete closure of the distal epiphysis associated with nonunion of the epiphysis of the head indicates that the age of the individual is somewhere within the fifteen to twenty-year period.

Further differentiation of age within each of these three particular periods depends chiefly upon (1) the dentition, in those individuals below the fifteen-year limit, (2) a close study and correlation of the stages of union exhibited by the various uniting epiphyses, in individuals within the fifteen to twenty-year period, and (3) in individuals above the upper limit of the true epiphyseal period, upon the stage of union of the marginal epiphyses of the scapula and innominate bone, heads of the ribs and sternal epiphysis of the clavicle, and in particular the symphysis pubis and other metamorphic age changes associated with the pelvis (v. supra p. 72). It is with the second of the above periods that we are particularly concerned and with it the remainder of this section deals.

Individuals within the fifteen to twenty-year period, especially those of the eighteenth or nineteenth years, invariably show all stages of epiphyseal union going on at the same time. This is to be expected when it is considered that all the epiphyses of the body so far studied unite in a comparatively short period of time. The first impression of the epiphyseal activity of this period is apt to be one of apparent confusion of simultaneous events. When several skeletons of the same age are compared, however, it becomes evident that within this group of apparently simultaneously uniting epiphyses there is a definite time order of union. Furthermore, the particular combination of stages of epiphyseal union in the case of any single individual, which can quite easily be presented in graphic form (v. Fig. 12), is essentially the same in all individuals of the same age. The regularity with which particular combinations of different stages of epiphyseal union become associated with definite age periods, and prove constant for all individuals in these respective age periods, is a fact of primary importance. It provides foundation for the practical application of epiphyseal union to the determination of age in Man.

Plate I presents in graphic form a correlation of these different combinations of epiphyseal stages of union with their specific time of occurrence. It will be noted that the various heights of the graphs in the figures represent the different stages of epiphyseal union mentioned in an earlier section of this paper; namely, (1) the stage of no union, in which case the space is left vacant, (2) the stage of beginning union, (3) the stage of recent union, and (4) the stage of complete union. It should be noted further that the phases of union of the various epiphyses are plotted to represent, not the condition in a particular individual, nor the average of several individuals, but the modal condition, namely, that condition presented by the largest number of individuals of that particular age. This plate is concerned primarily with the date of epiphyseal union, a fact which, in this particular series of skeletons, necessitates placing the lower age limit at seventeen years. The cross-lined figures inserted between those of the definite year periods are interpolated graphs representing borderline conditions occasionally found in either of the two adjoining year periods. This illustrates the full extent of the individual variation found in the date of epiphyseal union.

In this plate the epiphyses of the limb bones and those of the other bones considered are arranged in two groups, differing chiefly in the length of their respective time ranges of epiphyseal activity. The period of active epiphyseal union in the limb bones, for instance, comes to an end with the twentieth year. That of the various epiphyses of the scapula, os innominatum, and ribs extends through the twenty-second year, while union of the sternal epiphysis of the clavicle is just beginning in the twenty-second year and will continue, although not shown in Plate I, until the twenty-eighth year. It must be noted also that only two epiphyses are completely united in the seventeenth year. Although a few additional epiphyses begin their union in the seventeenth year, yet the eighteenth and nineteenth years stand out prominently as the years of active union of the epiphyses of the long bones (also v. Fig. 11).

The innominate bone attracts attention in a study of Plate I on account of having an additional epiphysis beginning to unite in practically every succeeding year after the seventeenth. Thus the tuberosity of the ischium usually begins its union in the eighteenth year, the crest of the ilium in the nineteenth, the ramal epiphysis in the twentieth or twenty-first, and complete union in the latter takes place in the twenty-second

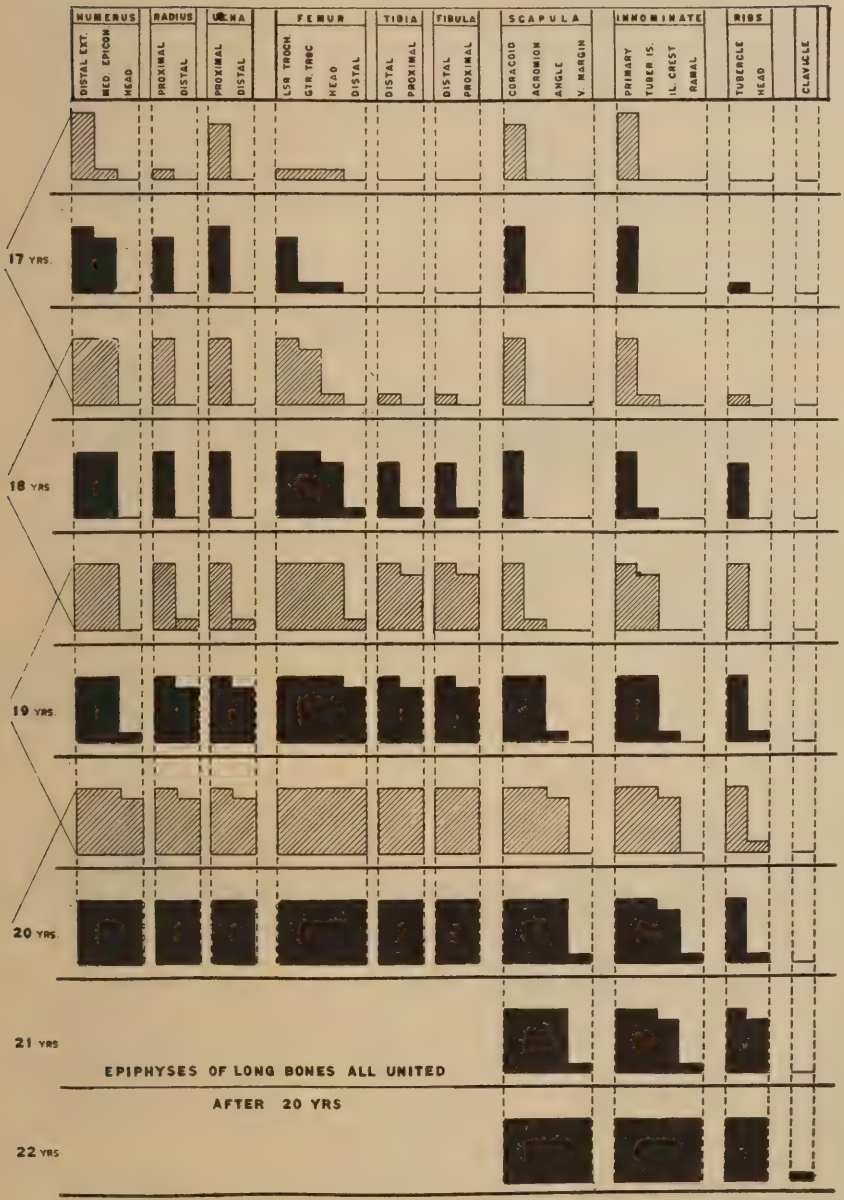

Plate I. Combinations of phases of epiphyseal union plotted against definite age periods.

year. This successive union of the lesser epiphyses of the os innominatum has proved to be of considerable value in the corroboration of other evidences of age in this particular period.

Application of Data to the Determination of Age

At the outset it may be stated that the determination of age depends not so much upon the condition of any one or two epiphyses as upon the general condition of all epiphyses of the body. In the preceding section the various phases of union of the epiphyses at any particular time were correlated with the definite dates of their occurrence, and the result graphically presented in Plate I. This plate illustrates the close resemblance of the graphs in question to the varying patterns of notches on keys operating the conventional barrel and tumbler locks. A series of keys, each of slightly different notch pattern, and one for each year, is thus presented. Owing to the remarkable constancy in sequence of epiphyseal union, once the process has started, the phases of epiphyseal union for any particular individual when similarly plotted in graphic fashion will present the picture of a key showing a very strong similarity to one or the other of those already plotted from the known-age series of skeletons (Plate I). Use of this simple fact will be made in the paragraphs that follow.

We may now discuss one of the most interesting phases of the study, namely the determination of age in skeletons of unknown age. From an abundance of such material three skeletons will be chosen for examples of this application.

The first is skeleton No. 955, a young negro male for whom no definite age data are available. Taking advantage of the valuable evidence which the epiphyses of the humerus offer in orienting an individual with respect to the period of epiphyseal union (v. supra, p. 77), we first examine this bone. The epiphysis at the distal end of the humerus is firmly united; that of the head shows as yet no sign of union. These facts indicate that the individual is within the fifteen to twenty-year period. In order to interpret the evidence presented by the various stages of epiphyseal union in other parts of the skeleton, the condition of each epiphysis is next plotted in graphic form and the general epiphyseal pattern for this particular individual presented as Fig. 12. When compared with the similarly constructed graphs made from the known age material (Plate I), the epiphyseal key for skeleton 955 is found to fall within the eighteen-year period. The small amount of individual variation exhibited by this specimen is well within the normal limits as

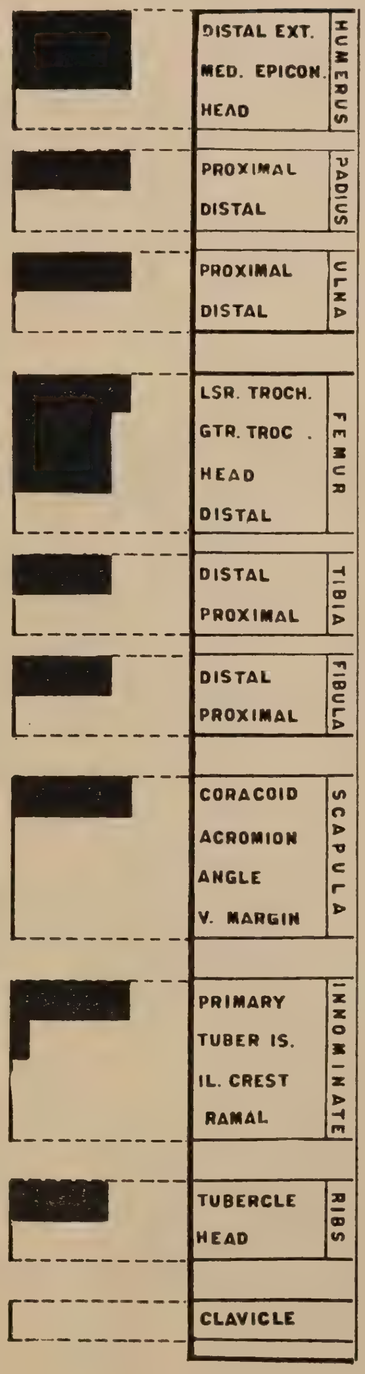

Fig. 12. Epiphyseal key of skeleton No. 955.

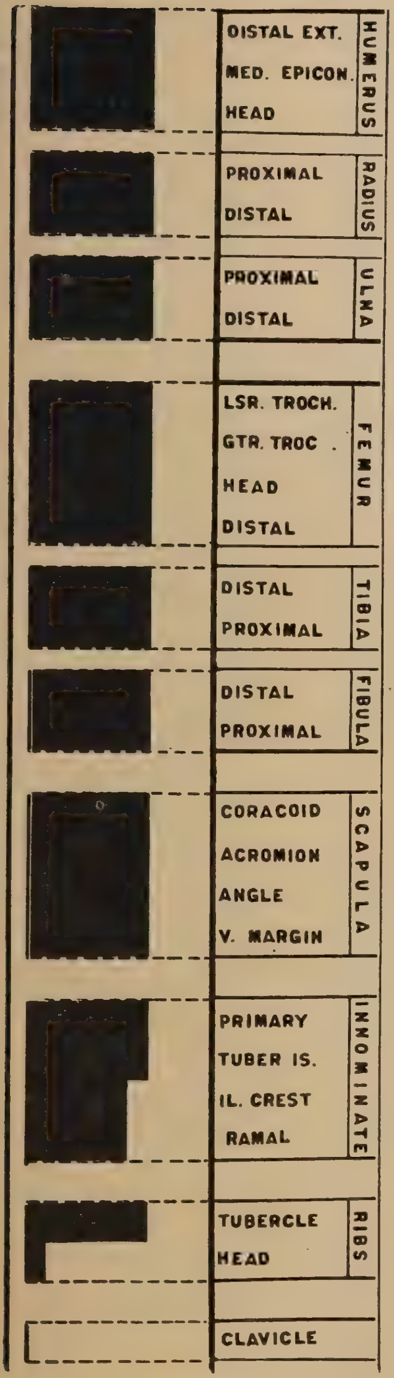

Fig. 13. Epiphyseal key of skeleton No. 0.210.

indicated by the cross-lined graphs. From the evidence presented by his epiphyses therefore, the young negro in question may be safely said to be eighteen years old. It is doubtful if this could have been determined with as much assurance if the evidence presented by the varying conditions of all his epiphyses had not been correlated in the way suggested above and compared to a standardized age key derived from the study of a large number of definitely age-known skeletons.

The second case is that of a mounted skeleton hanging in the anatomical lecture amphitheater. As to the age of this skeleton, which bears the number 0.210, there is no record of any kind. A rapid survey of the epiphyses of the limb bones reveals the fact that all of these are united, and that the individual may therefore be considered over twenty years of age. A glance at the still patent epiphysis at the sternal end of the clavicle, however, leads to the inference that he was most certainly under twenty-eight, and very probably (v. supra, pp. 73–4) under twenty-five years of age. The scapula, os innominatum, and ribs are next examined as being the sites of continued epiphyseal activity after the epiphyses of the limb bones have become united. The inferior angle of the scapula is firmly united; the condition of the epiphysis along the vertebral margin of the bone is indeterminable on account of its chipped and worn condition. As the epiphyses of both the os innominatum and the ribs show distinct evidence of having not all united, it can safely be inferred that the individual has not yet reached the age of twenty-two. The general epiphyseal status of the skeleton, shown in graphic form in Fig. 13, helps to orient more definitely this particular individual within the now narrowed period between twenty and twenty-two years. The general correspondence of the individual epiphyseal key of skeleton 0.210 to that of the twenty-one year period is seen at a glance. The approach to the twenty-two year period is seen in the recent union of the ramal epiphysis of the pelvis, however, so that the epiphyseal evidence may be said to indicate that this is the skeleton of an individual of certainly not less than twenty-one years of age, and probably nearer twenty-two years.

The third case illustrating the application of the foregoing observations to the determination of age is that of the skeletons of an adolescent female Indian (No. 13) one of a group of skeletons obtained by Dr. Todd, through the courtesy of the Kelley's Island Lime and Transport Co., from a serpentine burial mound on Kelley's Island in Lake Erie. Further interest attaches to this skeleton on account of fetal bones found in situ within the pelvis revealing the presence of twin pregnancy (Fig. 14).

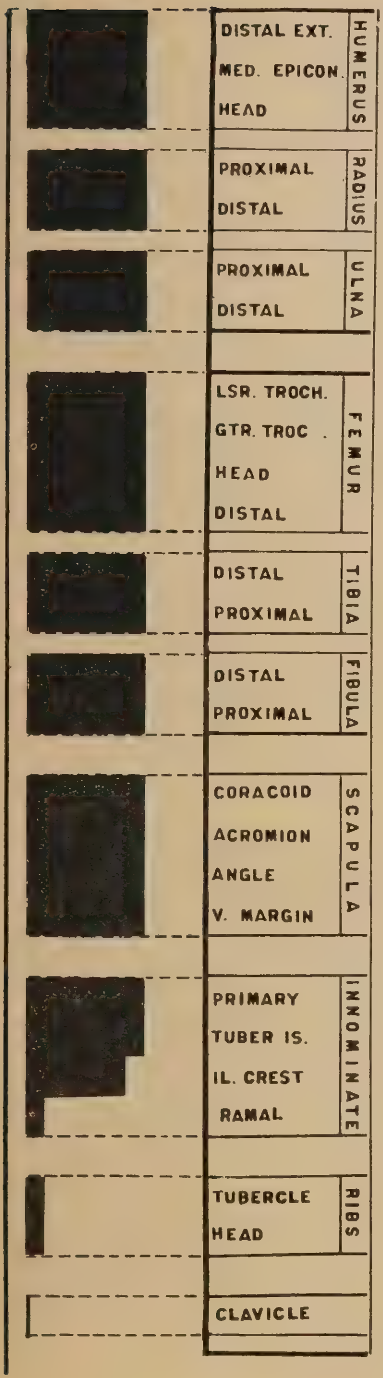

FIG. 15. Epiphyseal key of King Akhenaten.

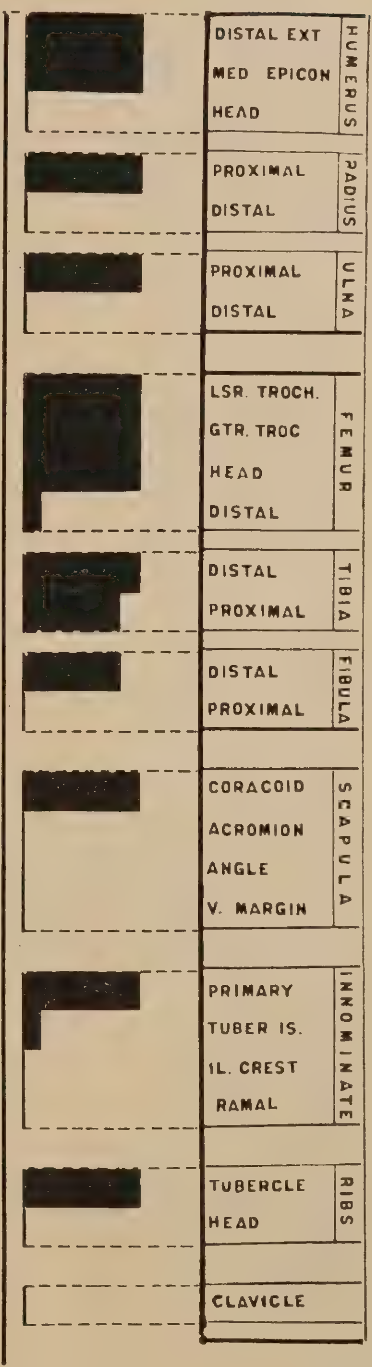

FIG. 14. Epiphyseal key of skeleton No. I-13.

The ends of the limb bones of the skeleton, with the exception of the fibulae, are sufficiently well preserved to afford excellent evidence of the condition of the epiphyses. The scapulae are too fragmentary to lend assistance although the left coracoid is firmly united. Both the innominate bones and the ribs are sufficiently intact to show clearly the condition of all their various epiphyses. A brief survey of the epiphyseal condition reveals at once that the individual was in the very midst of that intensive period of epiphyseal activity in which practically every one of the epiphyses of the limb bones exhibits one or another stage of epiphyseal union. Correlating the combined evidence of all these, and expressing the result graphically in the form of the individual epiphyseal key, Fig. 14, the skeleton is seen very definitely to have been in the middle of the eighteen-year old period. Again it is doubtful if this fact could have been determined with as much assurance if the evidence presented by the varying conditions of all the epiphyses of the body had not been graphically correlated and compared with a standardized age key.

To archeologists and students of ancient history, the question of the age of historical personages at death is often of great moment. A case in point, and one of timely interest, is that of the age of Akhenaten (or Khounaitonou), the heretic king of the XVIII Dynasty of ancient Egypt and the father-in-law of the youthful king Tutankhamen whose royal burial tomb has recently been discovered, and concerning whose own age there is also considerable interest. Regarding the age of Akhenaten, Professor Elliot Smith states first of all that "it is difficult from the anatomical evidence to assign an age to this skeleton sufficiently great to satisfy the demands of most historians, who want at least 30 years into which to crowd the events of Khouniatonou's eventful reign." And further, after carefully noting the condition of the various epiphyses of the body and making a detailed statement of these findings, Professor Elliot Smith concludes, "If we take into consideration all the facts set forth in this statement, not only the data concerning the immaturity of certain bones, but also those of the fully ossified parts of the skeleton; and bear in mind the wide range of variation of the control figures—in some cases as much as ten years between different authorities' estimates of when particular bones cease growing—upon which any argument as to age must be based; two judgments emerge quite clearly from this mass of apparent contradictions: (a) that, if we accept the generally admitted criteria, this skeleton is that of a man about twenty-five or twenty-six years of age; and (b) that no anatomist would be justified in refusing to admit that this individual may have been several years younger or older than the above estimate, which after all is based upon averages."

No better illustration could be found of the difficulties attending the determination of age by means of comparing the individual epiphyses of a body with the usual confused statements regarding their date of union. From Elliot Smith's very careful description of the condition of union in the case of each of the epiphyses of this royal Egyptian mummy, however, we are able to present the epiphyseal status of the body as a whole in the graphic form of the epiphyseal key shown in Fig. 15. Comparing this with the standardized keys it becomes quite evident, provided that our interpretation of the description and figure of the epiphysis of the crest of the ilium is correct, that Akhenaten at the time of his death was only twenty-two years old. One readily admits, of course, that a persistent sulcus along the cristal border of the ilium may occasionally simulate a delayed union of the iliac crest epiphysis, but in Akhenaten's case this probably has not occurred since the condition of his teeth and cranial sutures also demonstrate that he was quite obviously nearer the age of twenty-two than of twenty-five years.[5]

In this section the writer has endeavored to provide a relatively simple and yet accurate method for the determination of age of adolescent and young adult individuals on the basis of definite knowledge regarding the age and sequence of epiphyseal union. Again it must be emphasized that such a determination depends not upon whether single epiphyses here and there are or are not united, but upon a recognition of the various phases of union simultaneously going on in all the epiphyses of the body, and the determination on this basis of the actual "epiphyseal status" of the individual in question. The graphic method of presenting such epiphyseal findings in the case of any particular individual is herewith suggested as a means not only of determining this epiphyseal status, but also of comparing it when found with suitable standard graphs derived from a study of age-known material. Only in some such way as this can the evidence presented by all the epiphyses be properly weighed, correlated, and applied.

THE SEQUENCE OF EPIPHYSEAL UNION

The reader has probably noticed in Plate I that ten of the twenty-eight epiphyses charted were already in the process of union in the seventeen-year period. This implies a series of still earlier periods, beginning at a time when there are no epiphyses uniting, then successive stages during which the process of union makes its appearance in an increasing number of epiphyses until they have all exhibited the phenomenon in turn. The graphs in Plate II present such a series. In this plate the time element is strictly of secondary importance, yet it may be noted that No. 633 is known to be in the fourteen-fifteen year period, and that Nos. 519 and 437 are of the seventeen and eighteen-year periods, respectively. Interpolated between these are other individuals showing intermediate stages where these are necessary to illustrate the sequence in detail.

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[5] The evidence of age presented by a study of suture closure is shortly to be published (T. W. T.).

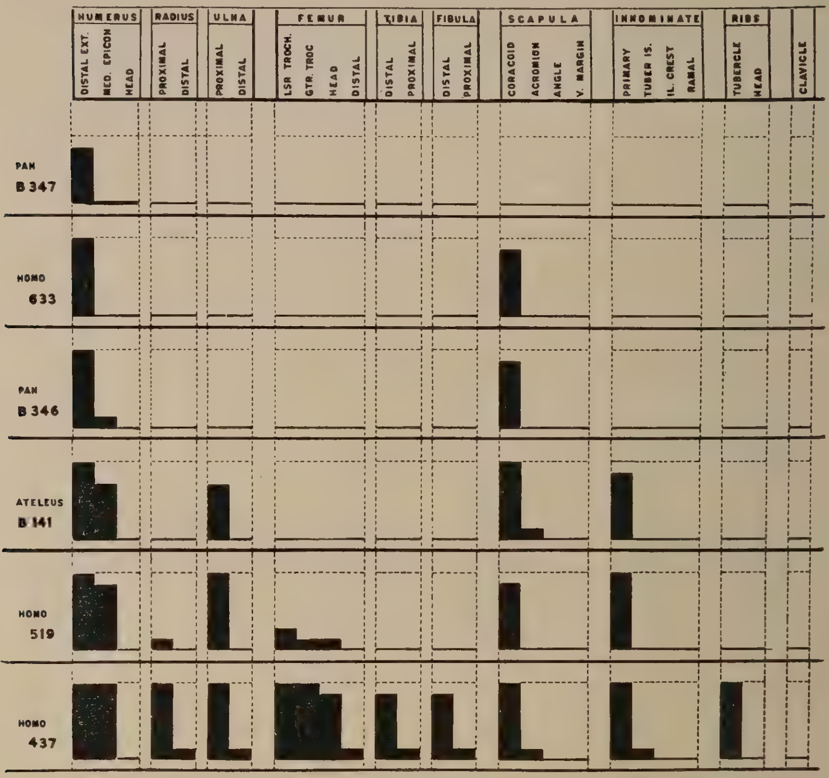

Plate II. Sequence of epiphyseal union.

In the beginning of this series, the epiphysis of the distal end of the humerus stands out conspicuously as the first of the entire body to unite. Following this there is excellent evidence in the case of several specimens, of which two only are indicated in the graphs, that the coracoid process next unites with the body of the scapula. The medial epicondyle of the humerus, although of the type of epiphysis noted above as exhibiting individual variation more often than those entering into articular formation, does not delay its union long after that of the distal epiphysis of the humerus.

The delay in union of the three primary elements of the os innominatum until after the coracoid and at least three of the four elbow epiphyses are normally on their way to complete union is also conclusively shown by this study. This particular sequence, which can be easily noted in any human or other primate material of the proper age is worthy of special notice in view of the generally accepted impression that the three innominate elements unite at an earlier age than any epiphyses. It was this impression which caused Wood Jones (loc. cit., p. 256), for instance, to class as abnormal those cases among ancient Egyptians in which the lower epiphyses of the humerus were found united in the presence of non-union of the primary elements of the pelvis. The phenomenon in question is nothing other than the perfectly normal sequence of epiphyseal union.

After union of the innominate elements the group of epiphyses at the proximal end of the femur next begins to unite. The period thus ushered in is one of general epiphyseal union during which all the remaining epiphyses except that of the head of the humerus are uniting more or less at the same time. A close examination of the sequence of events in this period, however, shows that the remaining epiphyses of the lower extremity take precedence over those yet to be united in the arm. The distal extremities of the tibia and fibula respectively precede those of the proximal ends of the same bones, while the distal extremity of the femur follows closely after and by its union completes the tale of union of the epiphyses of the lower limb.

In the case of the three epiphyses of the arm still waiting union, namely the two at the distal ends of radius and ulna and that of the head of the humerus, those at the wrist definitely unite before that at the shoulder. The head of the humerus it should be remembered, is clearly the last of the epiphyses of the limb bones to unite. Its union at the age of twenty years marks the close of a distinct phase of epiphyseal union during which all the epiphyses of the limb bones have become completely united.

Passing to the type of epiphyses occurring on the scapula, innominate bone, and ribs, it is observed that although there is a tendency on their part to exhibit a certain degree of individual variation in date of union a like tendency is not apparent in the sequence of their union. Thus union of the epiphyses at the inferior angle of the scapula always precedes that of the vertebral border of the same bone. In the case of the os innominatum the epiphysis of the ischial tuberosity invariably unites first, then that of the crest of the ilium, and finally that of the ischiopubic ramus. The epiphyses of the tuberosities of the ribs unite first, and are followed by those of the heads only after a considerable lapse of time.

The sternal epiphysis of the clavicle has already been noted as an exception both in the date of its union and length of time during which it exhibits activity. Not beginning until all the other epiphyses are completely united, and further delaying its process of union through a long drawn out and variable period, this erratic member of the family finally brings the program of epiphyseal union to a close in the twenty-eighth year.

Serially summarized the order of union of the various epiphyses is as follows:

Distal extremity of humerus
  (Medial epicondyle of humerus)
Coracoid process of scapula
Three primary elements of innominate bone
Head of radius
  (Olecranon of ulna)
Head of femur
  (Lesser and greater trochanters of femur)
  (Tuberosities of ribs)
Distal extremities of tibia and fibula
Proximal extremity of tibia
  (Proximal extremity of fibula)
Distal extremity of femur
Tuberosity of ischium
Distal extremities of radius and ulna
Head of humerus
Crest of ilium
Heads of ribs
Ramal epiphysis of pelvis
Clavicle

The constancy with which these epiphyses always unite in the same order cannot be too strongly emphasized. Although in a small percentage of cases the process of epiphyseal union as a whole may be slightly accelerated or retarded yet, when the process has once begun, *the sequence of union among the various epiphyses is observed to be exactly the same in every individual.*

FUNDAMENTAL NATURE OF EPIPHYSEAL UNION

As already indicated in the introduction, this study has chiefly concerned itself with certain facts bearing directly upon the date and order of epiphyseal union in the human body. Certain impressions regarding the fundamental nature of epiphyseal union, on the one hand, and the actual relation of this phenomenon to that of growth, on the other, are inevitable by-products of the investigation, and brief mention will be made of them in this section and the one immediately following.

The significance of the facts stated in the closing sentence of the preceding section, however interpreted, cannot be ignored. To ascertain whether or not this constancy of sequence in the union of epiphyses is purely a human characteristic, advantage was taken of the large collection of comparative material in the Hamann Museum at Western Reserve University to study the question of epiphyseal union in mammals generally. Such a study, the details of which will be the subject of a separate publication, not only confirms the constancy of a definite order in epiphyseal union in general but also demonstrates the fact that the particular sequence of epiphyseal union noted above is not a specific, generic, familial, or even ordinal characteristic, but that, although presenting a very few exceptions, it may be considered a general mammalian trait. Further, as I shall show in the section immediately following, the sequence of epiphyseal union remains unaltered in certain pathological states which are known to affect growth but not the appearance of germinal characters. It seems more than probable, therefore, that in sequence of epiphyseal union we are dealing not only with a true *germinal* character, one which is remarkably stable and very primitive.

Although it may be urged with some justice that this question is hereby raised rather than answered, nevertheless the suggestion and the reasons therefor are considered of sufficient value to be placed on record, with the anticipation that further evidence bearing upon this very important phase of the subject will be forthcoming.

EPIPHYSEAL UNION AND GROWTH

That there is a relationship, usually considered a very intimate one in fact, between epiphyses in general and the process of growth and that the union of the former and cessation of the latter are interdependent phenomena, is an anatomical dogma that few have had the occasion to question. Nor, with the seemingly universal acceptance of this view, has there been any real explanation as to just what this relation is or how it functions. It is not the intention of the writer at present to discuss this alleged relationship fully, but to suggest that this relationship exists purely as a secondary association.

Two distinct processes can be recognized as operating in the body; the quantitative process of *growth* on the one hand, and the purely qualitative process of *metamorphosis*[6] on the other. Although each maintains its separate course throughout the life cycle, yet there are times (the occurrence of various phases of dentition associated with more or less definite periods of infancy and childhood, for instance) when these two processes of growth and metamorphosis become more or less synchronous. Because of this secondary association these processes are often considered as one and the same thing. Such changes as fontanelle closure, dentition, secondary sexual changes, and epiphyseal union are all of them metamorphic processes, but because they coincide with certain periods marking off accepted stages in the growth history of the individual they are very commonly considered either the result of, or the cause of changes in the growth process itself.

To distinguish clearly between these two characters, growth and metamorphosis, it is necessary only to take account of those fortunately rare but interesting examples of developmental disharmony in which one of these processes has pursued its normal course while the other has been accelerated, retarded, or inhibited altogether. The indubitable witness of the various dwarfisms, of infantalisms, and acromegaly, to say nothing of a host of more subtle endocrinal distrophies, is that the two processes are not only distinct but also under entirely different control mechanisms. Pathological conditions such as the above are as yet very imperfectly understood, but it is plain that they affect bodily compensations only and not germinal characters, hence the disharmonies. The date of closure of the epiphyseal line does not seem to be associated with the amount or character of bone growth taking place at this region.

The two following cases are typical. The first is that of skeleton No.

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[6] Professor Stockard calls my attention to the misleading nature of the term metamorphosis. He points out that the zoologist understands by this term a perfectly well defined process which demands a complete break with former conditions. I readily grant the justice of Doctor Stockard's objection and propose to substitute for metamorphosis, until such time as I can find a more descriptive term, the word which Stockard himself suggests, namely *differentiation*. (T. W. T.)

337, showing growth abnormalities of an undetermined type associated with microcephaly (cranial capacity, 870 cc.) and megacolon in an individual known to have died at the age of thirty-one years. The epiphyses of this skeleton, however, have not yet all united, the general epiphyseal condition of the individual strongly suggesting that usually associated with the twenty-one - twenty-two year period. Cessation of growth in this individual very definitely has not waited until the union of the epiphyses.

The second case, skeleton No. 176, is that of an individual known to be thirty-nine years old at the time of death. This individual in addition to a glabrous facies, retained testes, and well marked indication of infantilism also exhibited a certain degree of gigantism. An osteoma was discovered in his pituitary fossa. The epiphyses, the character of the symphysis pubis, the general condition of the cranial sutures, the vascular pattern of the scapula, and other significant points in skeletal metamorphosis associated with age, all indicate a skeletal age twenty years younger than his known age. The epiphyseal key of this individual corresponds to that of the age of nineteen years. Again the growth process, has apparently not been influenced by nor in turn has it exerted any influence on the process of epiphyseal union.[7]

SUMMARY

1. The essential reliability of epiphyseal union as an indicator of age is established by an intensive study of the phenomenon in a series of definitely age-known skeletons.

2. In respect to their constancy of behavior, and the consequent relative dependability of their union as criteria of age, epiphyses may be divided into two classes.

3. The epiphyses of the so-called long bones (particularly the limb bones) are characterized by a remarkable degree of constancy, and, within the limitations of the period of activity, are to be considered the most reliable of all the various age indicators of the entire skeleton.

4. The epiphyses of another group of bones, namely, the innominate, scapula, ribs, and clavicle, are subject to a certain degree of individual variation in the date of their union and are of value in the determination of age only in the role of corroborators.

[7] Additional evidence of the apparent independence of the control mechanisms of epiphyseal union and growth is to be found among the numerous illustrations of mounted skeletons of dwarfs, achondroplasts, and other growth disharmonies in Gilford's ('11) work on "The disorders of post-natal growth and development."

5. The fifteen-twenty year period may be considered the real epiphyseal period of life.

6. The humerus possesses both limiting epiphyses of this important period, that of the distal extremity being the first and that of the head being the last epiphysis of this period to unite.

7. The age of greatest intensity of epiphyseal activity is the nineteenth year.

8. The os innominatum is the site of a larger number of reliable age indicators than any other skeletal entity of the entire body.

9. The accurate determination of age by observation of epiphyseal union depends not so much upon the condition of any one or two epiphyses as upon the correlation of the various stages of union found in all the epiphyses of the entire body.

10. The correlation of the various stages of union found among the different epiphyses of an individual at any particular time is most easily accomplished by a simple graphic representation of the varying stages found. By comparing the resulting "epiphyseal key" of the individual with a chart of seriated known-age keys the age of the individual in question is accurately determined.

11. The sequence of union among the various epiphyses is definite and constant.

12. This same sequence of epiphyseal union is found quite generally throughout the majority of other mammalian forms, and appears to be a remarkably constant and primitive mammalian character.

13. The phenomenon of epiphyseal union is essentially one of differentiation and should not be confused with the process of growth which manifests itself at the epiphyseal line. The control mechanisms of the two processes appear to be distinct.

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PATTERNS OF BRANCHING OF THE SUBCLAVIAN ARTERY IN WHITE AND NEGRO STOCKS

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Branches of the subclavian artery present so many variations from any given textbook pattern that it has seemed well to collect data with the purpose of finding for the material at hand (whites and mixed negroes) the curve of frequency of subclavian patterns, with the special purpose of comparing these patterns in the two races. Notable reports on branches of the subclavian artery have been furnished by Quain (1844), Gruber (1872), Thomson (1891), and Bean (1905).

MATERIAL

The present study[1] is based on records made by myself of 278 student dissections, 139 of each side. All dissections recorded were sufficiently complete to indicate the distribution of secondary trunks, so that no doubt is felt as to the identity of the branches recorded. Such subjects as were dissected only on one side by students were dissected on the other side for structures under investigation by members of the laboratory staff. All records of whites and some records of negroes were made at the University of Wisconsin (1913–16); most records of negroes were made at the University of Mississippi (1917–22). Of the 139 subjects examined 52 were whites (43 male and 9 female), and 87 were negroes (78 male and 9 female).

BRANCHES

THE THYREO-CERVICAL TRUNK

For purposes of comparison it is useful to find some one or more patterns of subclavian branching which may be set up as normal in the sense of most frequent. Choosing the thyreo-cervical trunk as a point of departure because of its numerous variations, my findings are presented in Table I with accompanying Charts I and II. This graphic method, in part taken directly from Thomson, makes possible a detailed presentation of all the observed facts with a minimum of description.

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[1] This and other statistical studies are pursuant to the general plan of dissecting room investigation set forth by Dr. C. R. Bardeen (1901). Also to Dr. Bardeen I am indebted for personal advice regarding the form of record chart used in this study.

Am. J. Phys. Anthrop., 1924, Vol. VII, No. 1.

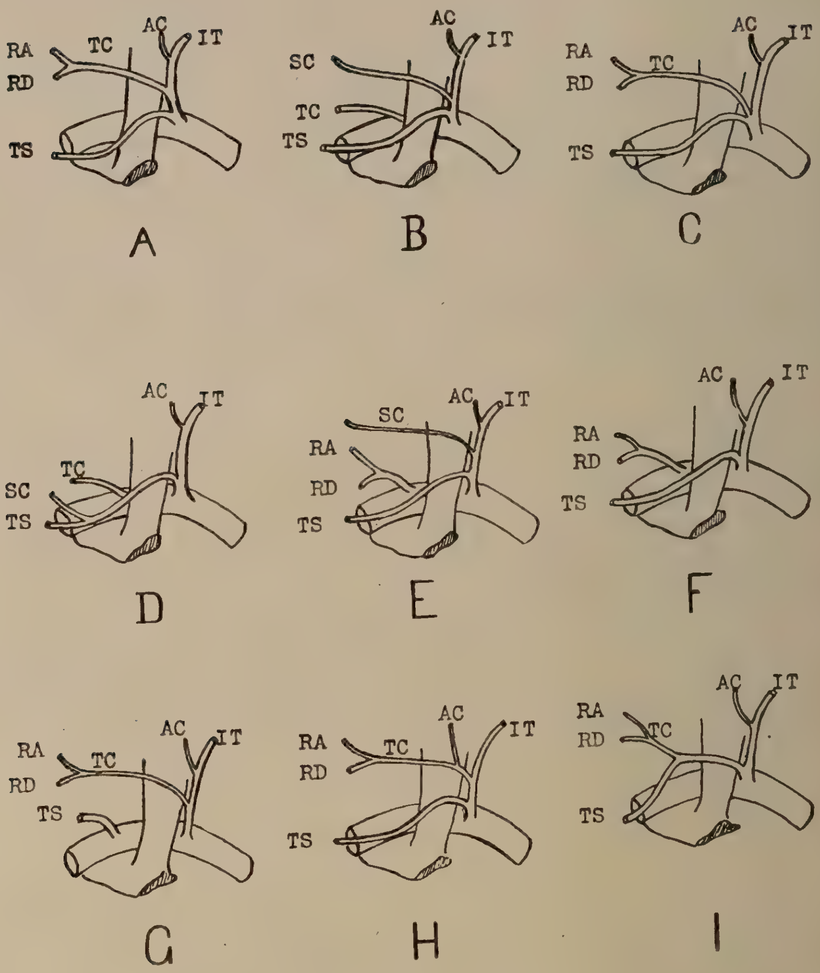


Chart I (modified from Thomson)

TS, transverse scapular artery; TC, transverse cervical artery; RA, ascending branch transverse cervical art. RD, descending branch transverse cervical art. AC, ascending cervical artery; IT, inferior thyreoid artery; SC, superficial cervical artery; IM, internal mammary artery; V, vertebral artery; CC, common carotid artery.

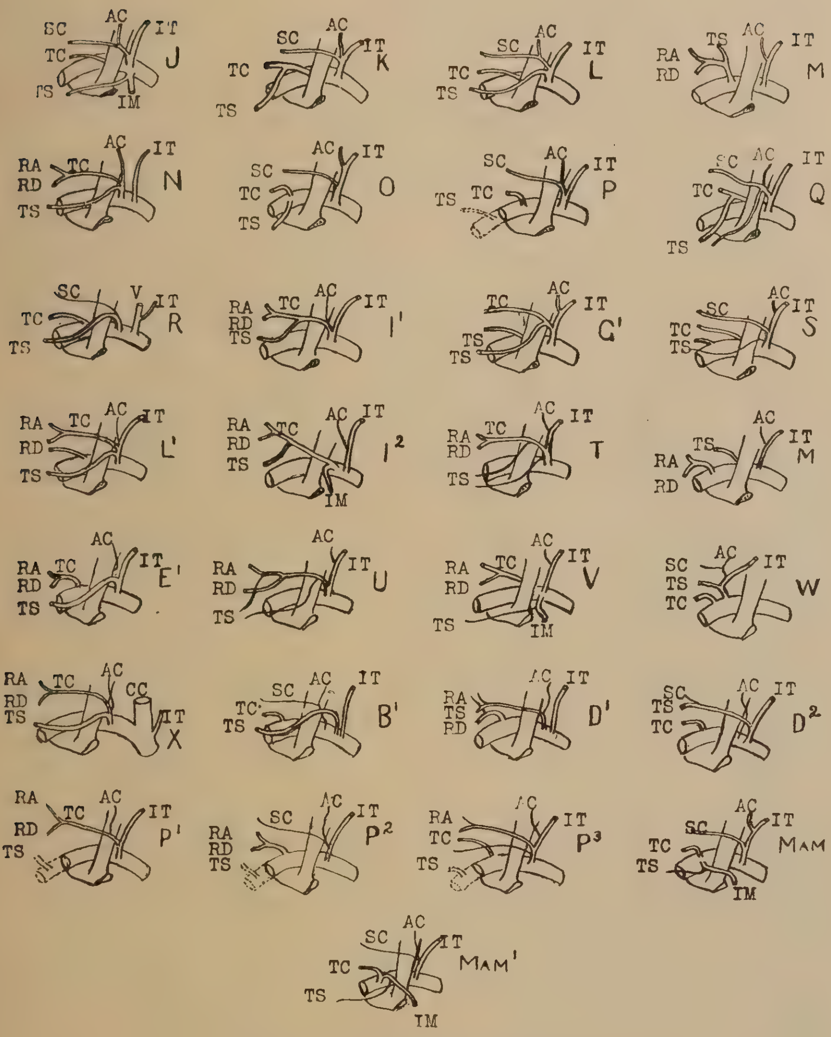


Chart II (modified from Thomson)
Lettering same as in Chart I

From the table and charts it is seen that patterns A and B are each many times as frequent as any other one pattern. In fact one or other of these two patterns is invariably figured in current textbook presentation. Cunningham, Morris, and Gray select pattern A; Quain, Toldt, and Spalteholz select pattern B. Since my own records show the two

TABLE I
INCIDENCE OF PATTERNS OF THE THYREO-CERVICAL TRUNK OR ITS COMPONENTS
BASED ON CHARTS I AND II
THOMSON, 544 OBSERVATIONS
PRESENT REPORT, 278 OBSERVATIONS—104 WHITE, 174 NEGRO SPECIMENS.

Pattern	Thomson	PRESENT REPORT				
	in 544	in 278	Whites		Negroes	
			in 104	per 1000	in 174	per 1000
A	160	85	45	*432.6*	40	*229.9*
B	121	88	37	*355.7*	51	*293.1*
C	48	9	3	*28.8*	6	*34.4*
D	39	15	3	*28.8*	12	*68.9*
E	24	9	1	*9.6*	8	*45.9*
F	23	5			5	*28.7*
G	20	7			7	*40.3*
H	16	7	2	*19.2*	5	*28.7*
I	14	2	2	*19.2*		
J	8	4	1	*9.6*	2	*17.2*
K	8	2			2	*11.5*
L	7	6	1	*9.6*	5	*28.7*
M	10					
N	5	5	4	*38.4*	1	*5.7*
O	4					
P	4	2			2	*11.5*
Q	3	4			4	*22.9*
R	3	1			1	*5.7*
G^1	3	2			2	*11.5*
I^1	3	2	1	*9.6*	1	*5.7*
S	2					
T	1	2			2	*11.5*
L^1	2	2			2	*11.5*
I^2	2	2	1	*9.6*	2	*5.7*
M^1	2	2			2	*11.5*
E^1	1	1			1	*5.7*
U	1	2			2	*11.5*
V	1					
W	1					
X	1					
B^1	1	3	1	*9.6*	2	*11.5*
D^1	1	2	1	*9.6*	1	*5.7*
D^2	1	2			2	*11.5*
P^1	2	2	1	*9.6*	1	*5.7*
P^2	1	1			1	*5.7*
P^3	1					
Mam		1			1	*5.7*
Mam^1		1			1	*5.7*

patterns so nearly equal in frequency as to offer no grounds for choice, the present report will designate both patterns as normal.

It is shown in Table I that pattern B or its closely allied patterns D, D^1, D^2, E, E^1, F, G, G^1, L, and L^1 are as a group more frequent in negroes than in whites; in fact all these allied patterns but D^2 are highly or exclusively incident in negroes. Pattern A and its allied patterns C, H, I, I^1, and N as a group show a higher incidence in whites than in negroes. How general is this incidence of one group of patterns in whites and another group in negroes could only be determined by a broad collective investigation. The facts of incidence reported above are not offered to support any generalization.

INCIDENCE OF PATTERNS A AND B ON RIGHT AND LEFT SIDES

Bean ('04, '05) has found that branches of the subclavian artery differ in their origin on the two sides of the body, pattern A or its equivalent being more frequent on the left side, pattern B or its equivalent more frequent on the right side. My own records examined for this point give the results summarized in Table II. From these results it appears that negroes show some tendency toward pattern B on the right side, and whites a negligible tendency toward pattern A on the left side. But it further appears that negroes show a reverse tendency toward pattern A on the left, and whites a reverse tendency toward pattern B on the right. Also it should be noted that patterns allied to B, already mentioned as prevalent in negroes, are in the aggregate more frequent on the left than on the right side, while patterns allied to A show a slight tendency toward the right. From such a state of facts it is plain that nothing worth while can be gathered in support of Bean's findings. Rather one can appreciate the attitude of Thomson, who, in summarizing his report on the thyroid axis, says, "As to the relative frequency of variations on the right and left sides of the neck, the results obtained are not such as enable us to draw any definite conclusions; indeed, there appears to be no greater tendency for the occurrence of these varieties on one side more than the other." Briefly, what Thomson has said of variations, my own findings show to be equally true of normals as applied to the subcalvian artery.

THE VERTEBRAL ARTERY

The vertebral artery was found arising from the first portion of the subclavian in all but three cases. In a case of anomalous right subclavian artery arising from the deep dorsal left of the aortic arch (this anomaly has been figured in a separate report, De Garis '23) the vertebral artery was a low branch of the right common carotid artery, (negro). Also there were two instances of the left vertebral artery coming directly from the aorta between left common carotid and left subclavian arteries, (2 negroes). A fourth variation was that of the vertebral artery furnishing the inferior thyreoid artery (negro), being pattern R. Thus with only four variations in 278 specimens the vertebral artery is seen to be very constant in origin and distribution; in these respects the most constant of all subclavian branches. In size, however, it showed wide variations, when compared with its fellow of the opposite side, especially when accompanied by very large or very small internal carotid arteries.

TABLE II

INCIDENCE OF PATTERNS A AND B OR ALLIED PATTERNS ON RIGHT AND LEFT SIDES OF WHITES AND NEGROES

Pattern A			
Whites 45 observations		Negroes 40 observations	
right 22	left 23	right 23	left 17
Pattern B			
Whites 37 observations		Negroes 51 observations	
right 16	left 21	right 29	left 22
Patterns allied to A(C, H, I, I^1, N)			
Whites 12 observations		Negroes 13 observations	
right 7	left 5	right 8	left 5
Patterns allied to B (D, D^1, D^2, E, E^1, F, G, G^1, L, L^1)			
Whites 6 observations		Negroes 45 observations	
right 3	left 3	right 19	left 26

THE INTERNAL MAMMARY ARTERY

The internal mammary artery was found quite variable. It showed a decided tendency to group with the thyreo-cervical trunk, the two frequently arising in juxtaposition. In seven instances (2 whites, 5 negroes) the internal mammary artery and thyreo-cervical trunk came off by a common stem. In three instances (1 white, 2 negroes) the internal mammary came off from a common stem of origin of the transverse scapular and transverse cervical arteries, (pattern I^2). In three instances (1 white, 2 negroes) the internal mammary gave rise to the transverse scapular artery. (pattern J). In two instances (2 negroes) the internal mammary was widely separated from the thyreo-cervical trunk, taking origin from the third part of the subclavian artery, and presenting arrangements in part similar to those shown by Quain in his plate 21, figs. 6, 7, 8, and 10, also in part similar to conditions described by Gruber. In my cases the anomalous internal mammary artery passed ventrally and medially across the scalenous anterior muscle and dipped under the first rib to the usual thoracic course. In one of these instances the internal mammary arose contiguous to the transverse cervical and gave off the transverse scapular artery, (pattern Mam); in the other instance it gave off both transverse cervical and transverse scapular arteries, (pattern Mam[1]). In both cases the inferior thyroid artery came off from the first portion of the subclavian artery instead of from a common trunk with the anomalous internal mammary as variously figured by Quain and Gruber.

Thus far it may be noted that all variations of the internal mammary artery have been associated with some degree of variation in the thyreo-cervical trunk or its components. However, there was one variation not so associated, namely the "lateral" branch, mentioned by Quain, and found by Bean five times in twenty-eight subjects. This branch usually came off from the internal mammary under the first rib, and sometimes was in size comparable to the internal mammary itself. The most frequent course of the "lateral" branch was downward along the inner side of the thoracic wall somewhat ventral to the mid-axillary line, anastomosing with the intercostal arteries and terminating on the diaphragm. In one case it was represented by two arteries arising in common, the larger reaching the diaphragm almost exactly along the mid-axillary line, the smaller terminating in the region of the chest wall under the nipple. The subject in which this occurred was a negress.

My material contained 22 instances of the "lateral" branch, five subjects showing bilateral symmetry in respect to this variation, (4 negroes, 1 white). Of the remaining 12 instances 9 were in negroes.

THE COSTO-CERVICAL TRUNK

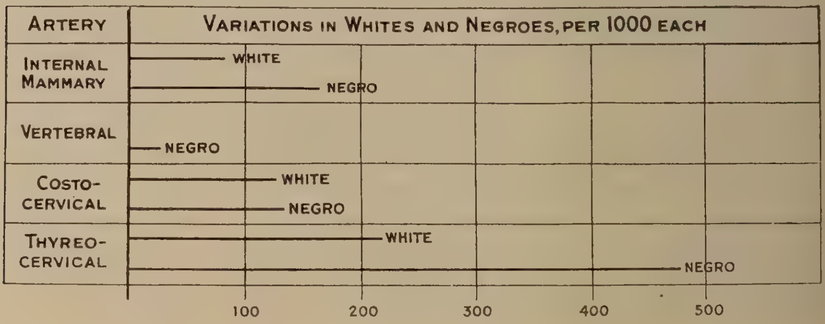
There is a current statement that the costo-cervical trunk arises from the subclavian artery part one on the left side, and part two on the right side. My findings in the main bear out this statement. Of the 278 subclavian arteries examined, 242 presented the trunk. In 11 cases this trunk arose from the subclavian behind the medial border of the m. scalenus anterior (2 right, 9 left); in 112 it was entirely medial to the m. scalenus anterior (10 right, 102 left); in 119 it was entirely behind the m. scalenus anterior (106 right, 13 left). It may seem logical to class as variations all trunks that do not bear out the current statement cited above. But my records are complicated by the following circumstances: whether the trunks came off behind the m. scalenus anterior or medial to it, all but six of them were contiguous to the medial border of the muscle. Mere weight of figures makes contiguity to this border the normal relation. And yet the six trunks not having this relation conformed in detail to the current statement. Therefore, lacking any definite standards within the above limits, it suffices to say that the normal origin of the costo-cervical trunk is from the subclavian artery parts one or two, usually contiguous to the junction of these two parts.

Of the remaining 36 subclavian arteries not having a costo-cervical trunk, 28 showed the superior intercostal and deep cervical arteries arising separately, (11 whites, 17 negroes); 3 showed the deep cervical missing entirely, (3 negroes); one showed the deep cervical missing from the subclavian but supplied by the superficial cervical artery, (negro); one showed the deep cervical artery duplicated, the first thoracic nerve trunk to the brachial plexus passing between the components, (white); one showed the superior intercostal artery missing, (negro); 2 showed the superior intercostal artery passing between the necks of the ribs and the transverse processes, rather than in front of the necks of the ribs, (1 white, 1 negro). An explanation of this last condition is offered in Professor Robinson's chapter of the recent Cunningham text (1922), according to which the artery in such cases is formed from a postcostal rather than a precostal primitive channel.

INCIDENCE OF VARIATIONS IN WHITES AND NEGROES

These data, analyzed to determine the relative frequency of variations in branching patterns of the subclavian artery in whites and negroes, show a gross find of 173 variations, of which 42 are in white specimens, 131 in negro specimens. It should be understood that a number of

Chart III—Variations of Primary Trunks of the Subclavian Artery



specimens showed more than one variation. For purposes of comparison each variation is accounted separately. Expressing the number of variations in customary terms, there were in 1000 white specimens 403.8 variations (42/104), in 1000 negro specimens 752.8 variations (131/174). These variations are summarized in Table III, and the totals expressed graphically in Chart III.

TABLE III

VARIATIONS OF THE PRIMARY TRUNKS OF THE SUBCLAVIAN ARTERY SUMMARIZED
278 OBSERVATIONS—104 WHITE, 174 NEGRO SPECIMENS
173 VARIATIONS—42 WHITE (403.8/1000), 131 NEGRO (752.8/1000)

	WHITES	NEGROES
INTERNAL MAMMARY ARTERY		
In common with thyreo- cervical trunk	2	5
In common with trans. cervical and trans. scapular arteries, Pat. 1^2	1	2
In common with transverse scapular art. Pat. J	1	2
Giving rise to the "lateral" branch	5	17
From subclavian 3rd part, giving rise to the trans. scapular artery, Pat. Mam		1
From subclavian 3rd part, giving rise to trans. scapular and trans. cervical arts. Pat. Mam^1,		1
Total	9	28
In 1000	86.5	160.9
VERTEBRAL ARTERY		
From right common carotid (case of anomalous rt. subclavian artery		1
On left side from aorta		2
Giving rise to inferior thyroid artery, Pat. R		1
Total		4
In 1000		22.9
COSTO-CERVICAL TRUNK		
Superior intercostal and deep cervical arteries arising separately	11	17
Deep cervical artery duplicated	1	
Deep cervical artery from superficial cervical artery		1
Deep cervical artery wanting		3
Superior intercostal artery wanting		1
Superior intercostal artery passing between necks of ribs and transverse processes	1	1
Total	13	23
In 1000	125	132.1
THYREO-CERVICAL TRUNK		
Details in Table I (Patterns A and B normal)		
Total	22	83
In 1000	211.5	477
Apparent total variations	44	138
Correcting for variations counted twice[1]	2	7
Actual total variations	42	131
Total variations in 1000	403.8	752.8

[1] The following were counted twice, as variations both of the thyreo-cervical trunk and the internal mammary artery: Pat. I^2 (1 white, 2 negroes), Pat. J (1 white, 2 negroes), Pat, Mam (1 negro), Pat. Mam^1 (1 negro); as a variation both of the thyreo-cervical trunk and the vertebral artery, Pat. R (1 negro).

A previous report dealing with modes of origin of the subclavian artery (De Garis '23) has shown that of the variations recorded 2.8 per cent were in whites, 9.3 per cent in negroes.

This greater variation in negroes than in whites may be due in part to the factor of hybridization, since the American negro is customarily recognized as mixed. However, this factor seems hardly adequate to account for the high to very high incidence of variations in negro stock as measured by the normals of white stock.

In addition to the very important data of craniometry, which have long since established specific differences between the races, evidence continues to accumulate that negroes vary from whites in many other anatomic details. Todd ('21) in a thorough study of varieties of pelvis has found no practical disadvantage in working with American negro-white hybrid material, since differences between the white and negro stocks are readily detected. His studies convince him that the negroid type of pelvis is retained in the hybrid population. Numerical variability in the thoracicolumbar column has been found by Willis ('23) to be greater in negroes than in whites. Thompson, McBatts, and Danforth ('21) have reported a definitely higher incidence of the musculus palmaris longus in negroes than in whites. Bean and Baker ('19) have shown in a large series that both liver and spleen weights are higher in whites than in negroes. Bean ('22) has found that the sitting height varies with race, the index being high in yellow-browns, low in blacks, and intermediate in whites. In this connection he makes the significant statement that he has found racial differences which remove the negro farther from the remainder of mankind than any other group of people.

In the light of the foregoing citations from recent literature the present report, showing an incidence of subclavian variations almost twice as high in negro stock as in white stock, must suggest that this higher incidence in negro stock is something more than a casual result of hybridization. Rather arterial variation in an economic sense should be regarded as altered supply in response to altered demand, whether this altered demand be in the way of skeletal, visceral, muscular, or statural variation, also whether it be the expression of specific racial difference or indeterminate racial mixture.

DISCUSSION

No interpretation of variable branches of the subclavian artery is attempted in this report. Indeed, it is not clear how interpretations could safely be derived for branches of the subclavian artery alone, that is, apart from sources of supplemental supply, as carotid arteries proximal, axillary artery distal, aortic intercostal arteries dorsal to the subclavian interval. Senior ('19) has expressed a view which may well be cited in this connection: "Cases characterized by absence, or other gross variation, of one of the adult arteries are commonly classified as anomalies of the particular vessel most obviously affected. In consequence, however, of the very intimate interdependence of the alternative arterial routes which successively become available during the progress of development, it happens that arterial anomalies affect general arterial regions rather than individual vessels." This broad conception must appeal to any one who has collected arterial variations for a time; also it must indicate the hazards of interpretation confined to purely arbitrary limits.

Only certain general statements need be made here. The important literature on arterial development has been reviewed and investigation presented by Woollard ('22), who has studied the forelimb arteries in pig by injection methods. He concludes that an individual arterial tube goes through three stages: (1) stage of the capillary net; (2) retiform stage with enlarged tubes, showing island-formation, coalescence, and tendency to fuse; (3) stage of the definitive stem; each stage in response to definite physiological demands. The fact that a relatively large number of arteries of a given kind, e. g. the subclavian, do emerge from the capillary net and retiform stages in conformity to some normal pattern of branching is ample proof that the definite physiological demands to which these arteries have been responding as they develop are also quite uniform demands for a particular species or a particular race. Even a slight change in the physiological demand must be reflected, if not greatly magnified, in the arterial pattern. And since muscles constitute a very considerable part of the physiological demand, especially on limb arteries as the subclavian, muscular variation should practically establish arterial variation. Variation in subclavian patterns having already been shown by the present report to be highly incident in negroes, it is significant to find a concise statement regarding muscular variation, such, for example, as that of Chudzinski, quoted by Le Double (1897) to the effect that "les anomalies musculaires sont plus communes dans les races de couleur que dans la race blanche." It must be clearly understood, however, that what is here spoken of as anomaly, or in my own discussion as variation, may be quite often anomaly or variation only according to the normal of white stock, since it appears that the normals of other stock remain to be determined.

SUMMARY

1. Two normal patterns of branching of the subclavian artery have been established in reference to the thyreo-cervical trunk or its components. In one of the normals (pattern A) the thyreo-cervical trunk gives rise to the following arteries: inferior thyreoid, transverse cervical, transverse scapular, and ascending cervical. In the other normal (pattern B) the thyreo-cervical trunk fails to give rise to the transverse cervical artery, giving rise instead to the superficial cervical artery which in whole or in part replaces the ascending branch of the transverse cervical artery. This latter artery in such cases comes off near the junction of the second and third parts of the subclavian artery.

2. Pattern B and patterns allied to it are as a group found highly incident in negroes.

3. There is nothing in the data presented here to support the statement that patterns A or B or their equivalents occur more frequently on one side than on the other.

4. The internal mammary artery tends to group with the thyreo-cervical trunk, at times furnishing the transverse scapular artery.

5. The vertebral artery is found to be the most constant stem of the subclavian artery, both in origin and in distribution. In all but three instances it came off from the subclavian part one.

6. The costo-cervical trunk in the main conforms to the rule of arising from part one of the subclavian artery on the left, and from part two on the right, the most constant relation of the trunk being that of contiguity to the medial border of the scalenus anterior muscle.

7. The female specimens studied here present only one variation that might possibly be construed as an expression of sex, namely doubling of the "lateral" branch of the internal mammary artery in a negress.

8. A higher incidence of variation in subclavian patterns has been shown for negro than for white stock, the comparison being expressed as follows: 403.8 variations in 1000 whites (42/104), 752.8 variations in 1000 negroes (131/174). This greater variation in negroes may be due in part to hybridization. In part also it may well be due to specific difference in the arterial pattern of colored stocks as compared in detail to the normal of white stock, this specific difference in arterial pattern being in response to other specific differences, as of viscera, muscle, skeleton, stature. It is yet to be determined to what extent the patterns found normal for white stock can be applied as normal for colored stocks.

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[1] Courtesy of the University of Chicago Libraries.

[2] Photostat plates, courtesy of the Library of the Surgeon General.

NEW DATA ON THE TEETH OF EARLY MAN AND CERTAIN FOSSIL EUROPEAN APES

ALEŠ HRDLIČKA

I. THE TEETH OF FOSSIL APES
II. THE TEETH OF EARLY MAN
III. THE PRECUSPIDAL AND POSTCUSPIDAL FOSSA
IV. ADDITIONAL NOTES UPON THE "CINGULUM"

GENERAL REMARKS

During the summer of 1923 the writer has been able to once more visit the various European Institutions in which the more valuable skeletal remains of early man and fossil European apes are preserved, and the occasion was utilized for careful reexamination and remeasurement of the teeth of these remains, more particularly of the lower molars, new data on which since the recent work on the Piltdown jaw have become of great importance.[1]

Measurements of the teeth of most of the remains of early man and higher apes in Europe have been made and published before, some by the writer himself. But they were made by almost as many different methods and instruments as individuals. Measurements of teeth are as well known in themselves extraordinarily difficult, in addition to which there is no definite agreement as yet as to the exact points from or the precise manner in which to measure. As a result hardly any two separate measurements of the same teeth, even by the same observer, give absolutely the same values, and occasionally the differences are so marked that the student loses confidence in the records. Nor is he helped by the casts of the various specimens, for due to imperfections of technique and changes in plaster these generally give results on which one can place no great reliance.

Yet there is a growing evidence that accurate measurements of the

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[1] The writer is happy to say that he was everywhere received cordially and given all possible facilities. A grateful acknowledgment of aid rendered is due especially to Professor Smith Woodward, Mr. Pycraft and Sir Arthur Keith, London; Professor Bolk, Amsterdam; Eugene Dubois, Haarlem; Rutot, Brussels; Fraipont & Lohest, Liège; Dr. Karl Beuerlen, Tübingen; Professor Salomon and his Assistant, Heidelberg; Martin Schmidt, Stuttgart; Wegner, Frankfort-a-M.; Schuchart, Berlin; Dr. H. O. Junker and Herr E. Lindig, Weimar; Professor Matiegka, Prague; Dr. Absolon, Brno; Professor Szombathy, Vienna; Gorjanovič Kramberger, Zagreb; Mayet and Arcelin, Lyon; Dr. Henri Martin, La Quina; and the Curator of the Museum at Perigueux, southern France.

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teeth and particularly of the lower molars will be of signal value in the studies of human evolution and variation. The teeth have changed with time in their absolute as well as in their relative dimensions, and they are evidently still changing. There is therefore an urgent need of uniform data on all the important early material in this line, data that could safely be used by every worker as basis for comparison.

To obtain such data as far as possible was the writer's aim during this summer; but the effort would have been quite useless without the formulation beforehand of a definite, uniform method of measurement, and such a method was developed, as has already been described in this Journal.[1] The greatest former difficulty with measurements of teeth, particularly the molars, was that while some of the teeth were loose others were still in position in the jaws. Now on a loose molar, particularly one from the lower jaw, it is relatively easy to secure the maximum length and breadth as well as other dimensions; but on the same tooth when in position and close contact with the neighboring teeth, accurate measurement of the maximum length is often difficult if not impossible. A few trials in this direction will soon convince the student of this fact. The difficulties are due to the frequently irregular contour of the teeth and to the greater or lesser bulging of the enamel below the upper border of the crown, which cannot be reached by the instrument when the teeth are in close apposition. If we add to this the fact that the maximum lengths of the three molars in many instances give a greater total length than that of the three teeth measured as a whole, the desirability of seeking the maximum length of the crown becomes questionable.

The method arrived at by the writer was to measure the length of the molars along their median antero-posterior axis, in other words along the middle of the crown, from articulation (or contact) to articulation if the tooth is still in the jaw, or from the middle of the upper border of the articular facet anteriorly to a similar point of a similar facet posteriorly, in teeth that are loose. Even this method encounters some difficulties due to occasional notching of the anterior border of the tooth, or an absence or unusual position of facets, but on the whole it has proved easier and more satisfactory than the measurement of length maximum. With the breadth there are no such difficulties. All observers, it seems, take the greatest breadth of the tooth, and the measurement may be safely defined as the greatest breadth of the crown at right angles to the length as well as to the vertical (mid-crown–mid-root) diameter of the tooth.

The principles of the method having been settled, the next point was that of instruments. It was soon seen that the ordinary *compas d'épaisseur*, though accurate enough for other purposes and though its blunt branches are very useful for the measurement of the maximum breadth of the teeth, was not entirely satisfactory for measuring the tooth length. The best instrument for the latter measurement was found to be a pair of needle-pointed calipers, supplemented by a magnifying glass. The practice developed therefore to take the length of the tooth by the sharp pointed compass, under a magnifying glass, reading the measurement on a standard scale;[2] and to take the maximum breadth of the tooth with the blunt extremities of a sliding compass, the latter well tested as to accuracy.

In the case of the third molar which lacks the posterior contact facet and in all other cases where the contact facet is missing or displaced, the length is measured to where the upper edge of the facet would normally be if it existed. In the case of teeth presenting peculiar conditions the student must use his good trained commonsense.

Under these conditions results are obtained, particularly as to the length, that do not vary on repeated measurements more than, at most, two-tenths of a millimeter. With all due care, however, measurements on some teeth have to be repeated several times until the observer is fully satisfied as to the results. Such minutiae are quite necessary when dealing with the teeth of smaller Primates or with teeth of such importance as those of fossil anthropoids and early man; and they are indispensable when studying the relations of the teeth in the two sexes, on the two sides, or among themselves in the same individual.

The teeth that were measured or remeasured during the summer included the following:

FOSSIL APES

The lower molars of *Anthropodus Brancoi* in the Geologisch-Palaeontologisches Institut, Tübingen; and those of the
Dryopithecus fontani—Naturalien Sammlung, Stuttgart;
Dryopithecus suevicus (*rhen.*) Koken— Geologisch-Palaeontologisches Institut, Tübingen;
Dryopithecus rhenanus—Naturalien Sammlung, Stuttgart; and
Dryopithecus sp.—ibid.

EARLY MAN

The lower molars of the Piltdown Jaw—British Museum of Natural History;
The Mauer Jaw—Geologisch-Palaeontologisches Institut, Heidelberg;
Two jaws of Ehringsdorf—Städtisches Museum, Weimar;
Le Moustier youth—Museum für Kunstgewerbe, Berlin;
Spy skeletons—at the home of Professor Maxime Lohest, Liège;
Krapina remains—Narodni Muzej, Zagreb;

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[2] For which the rod of the sliding anthropometric compass is quite useful.

Aurignacian remains of Předmost—The Provincial Museum (of Natural History), Brno;
H. Aurignacensis Hauseri—Museum für Kunstgewerbe, Berlin; and
The Chancellade skull—Museum of Perigueux, France.[3]

In addition to the preceding, various specimens were seen that on account of wear could not be measured, or that were too far from man and the upper apes to be of much use in this connection.

I. THE TEETH OF FOSSIL APES

The question of the fossil anthropoid apes of Europe has not received and is not receiving as yet the attention it deserves. It is not even generally known, especially to anthropologists, that valuable remains of several species of anthropoid apes, not to count more distant forms, exist in the European museums. They are in particular the two and possibly more species ascribed to the genus *Dryopithecus*, represented by jaws or teeth some of which are exceedingly interesting.

The most important material in this respect is found in the Museum d'Histoire naturelle, Paris, in the Naturalien Sammlung in Stuttgart, and in the Geologisch-Palaeontologisches Institut, Tübingen. The two latter institutions contain the highly valuable and still problematical remains of anthropoid apes from the Bohnerz Alb. These remains consist essentially of a series of teeth and crowns of teeth. The larger number of these (namely 7) are preserved in Tübingen; the smaller number (3) in the Stuttgart institution. It seems that originally there were more of these teeth. They were described on two main occasions, by Branco[4] and Schlosser[5]; but the descriptions while giving a wealth of details and discussion are not entirely satisfactory from the standpoints of either identification or anthropology, and the illustrations of the teeth in both Branco and Schlosser when compared with the originals are found to be imperfect, in some instances so much so that it is with difficulty that the original can be identified with the illustration. It was also found by comparison on the spot that some casts of these teeth (Tübingen) agree but poorly with the originals.

The original teeth just mentioned are in a splendid state of preservation. They are no new finds, dating from the thirties to the latter part of the last century. They proceed from accidental finds in the now abandoned surface mining in the "Bohnerz" deposits of the mountainous (Alp) ranges not far from Tübingen. Their age in the concensus of opinion is early Pliocene, though some, if not all, might be later. A few of the teeth are complete, but the majority are represented only by the enamel shell of the crowns, which however is generally entire and in perfect preservation. The enamel is white and shiny, almost as in recent teeth, with here and there bluish-grey discoloration. As a result probably of fossilization it shows no tendency towards cracking.

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[3] The teeth of La Ferrassie and La Quina could alone not be measured. The former are still under study by Dr. Boule; the dimensions of the latter are given by Dr. Henri Martin in his "L'Homme fossile de La Quina," 8°, Paris, 1922.

[4] Branco (W.)—Die menschenähnliche Zähne aus dem Bohnerz der Schwäbischen Alb. *Jahresb. Ver. f. vaterl. Naturk.* Württ., 1898, sep, 8 , Stuttgart, 1898.

[5] Schlosser (M.)—Beiträge zur Kenntniss der Saügethierreste auf den süddeutschen Bohnerzen. *Geol. & Palaeontol. Abh.*, 1902, IX, H. 3.

The size and other characteristics of the teeth indicate very strongly the presence of more than one variety or species of high Primate and that even among those classed by former authors under the same name (*D. suevicus s. rhenanus*). A few of the crowns are remarkably near human, which explains how in the beginning they could have been taken for human. Thus the exceptional and highly interesting crown No. 7, Tübingen, comes very close in dimensions and general characteristics to the crowns of the Piltdown molars, though it differs from these in the somewhat tapering posterior (proximal) portion (a taper which is even more apparent in the remaining lower molar crowns of the series) and in a few other details of the surface of the crown; while crowns of nos. 2, 3 and 6 are also close to those of corresponding human teeth, without being quite identical.

The detailed notes and measurements on these teeth are as follows:

Anthropodus Brancoi, Schloss,[6] in Tübingen.

Branco, 1898, Pl. II, 11; Schlosser, 1902, Pl. I, 1, p. 7.

"Lower Pliocene-Bohnerz," from Salmendingen (half an hour's journey from Melchingen), Suabian Alb. "Left lower M_3".

Enamel of crown slightly bluish-white, shiny, roots chocolate. Contact facet plain anteriorly, absent posteriorly.

While identification (as to which tooth) is probably correct, the crown of the tooth bears considerable resemblance to some posterior deciduous lower premolars of man, but roots instead of being curved as in the premolar (about the germ of the permanent tooth) are straight and the crown is broadest in anterior third, tapering backwards. There are two fused roots anteriorly, one root posteriorly and their tips are not yet fully closed, showing the tooth to proceed from an immature subject. Cusps 3 labially, 2 lingually and much as in posterior milk premolar of man. Precuspidal fossa (for definition see further) marked, postcuspidal small.

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[6] The observations here given are not to be regarded as exhaustive new descriptions of the specimens, but merely as supplementary notes and data to what has already been published. A thorough re-study of the teeth in the light of modern knowledge is a growing necessity.

MEASUREMENTS

Length of Crown,	10.8 mm.	Total max. height of tooth[7] 11.8 mm.
Breadth, max.	8.–	Height of crown (enamel) from 5 mm.
Crown index	*74.1*	anteriorly to 3 mm. posteriorly.

Note: The reasons for the separation of this specimen from the other Bohnerz teeth as representing another genus are not apparent.

Dryopithecus font. Lart.; in Stuttgart.

(One card with the tooth reads "Salmendingen Bohnerz, Fleischer, 1876;" another—"Bohnerz bei Ebingen, Quat. Epoch, p. 746, in A. Quernstedt's Epochen der Natur, Tübingen, 1861, 745 *et seq.*").

Probably left lower M_2 or M_1; crown only; contact facets—low one anteriorly, regular posteriorly. Enamel in excellent state of preservation, cavity filled with whitish to chocolate fossilized dentine.

In its features the crown is merely like one of those attributed to *D. suev.* (*rhen.*) at Tübingen and it is not plain why the tooth has been separated as that of another species. From about its middle the crown tapers backwards.

The cusps, 5 in number, 3 labial 2 lingual, show slight attrition, more noticeable on the labial than the lingual side. Small precuspidal as well as postcuspidal fossa. Intercuspidal grooves rather deep.

Measurements: Length of crown, 10.9 mm.; breadth, max. 8.9; crown index, *81.7*. Height max. of crown (same labially as lingually,), 4mm.

Dryopithecus sp., in Stuttgart.

("Salmendingen. Orig. in Branco, Pl. II, Fig. 2." In same little box two other old tickets: 1. "3rd right lower molar of man; property of Professor Fleischer;" and 2. "Man. Middle right lower molar. Property of Professor Fleischer").

Right lower M_2 (probably). A whole tooth, with two roots (ant. and post.). Enamel white, at base old-ivory-like, shining; roots like ivory. The two roots are double but each thoroughly fused (separation groove marked ventrally but barely perceptible dorsally).

In general considerably human-like, but crown tapers backward. There are deep fissures between the labial cusps (much exaggerated in Branco's illustration) and there are present both a precuspidal (narrow but well marked) and a postcuspidal (small) fossa. There are 5 cusps, 3 labial 2 lingual, of which the anterior lingual is the highest.

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[7] Most prominent part of crown to extremity of roots.

Vertically the tooth is somewhat oblique, its axis inclining forward from the roots to the crown. There is no trace of any contact facet either in front or behind.

MEASUREMENTS

Length of crown, 12 mm.
Breadth max.[8] 9.8 mm.
Crown index, *81.7*
Height max. of crown (both labially and lingually, 6mm.
Total max. height of tooth (mid-crown—mid-root) 17mm.

Dryopithecus rhenanus Pohlig sp., in Stuttgart.

("linker unterer D_4 von oben, ½ nat, Grösse, Salmendingen Stuttgarter Sammlung, Orig. Jäger's "Anoplotherium" t. 5, f. 72–75"). "Tooth from Salmendingen, 1831. Trader Traziger." Schlosser, *Palaeont. Abh.*, IX, 14, Taf. I, 14, 14a, 14b. Crown only. No roots. Preservation as in the other teeth of this series.

Left lower anterior milk premolar. Has 5 sharp cusps, though the 5th is small. Precuspidal fossa well defined; postcuspidal not differentiated from large median. Cusps, 3 labial (last small) and 2 lingual. A marked fossa labially between first and median cusps with a small Carabelli tubercle. Upper part of crown is narrower anteriorly than posteriorly.

MEASUREMENTS

Length, 9.4 mm.
Breadth max.[9] 7 mm.
Crown index, *75.5*.
Max. height of crown anteriorly, 5.8 mm.
Max. height of crown posteriorly, 4.8 mm.

Dryopithecus suevicus (*rhen.*) Koken, in Tübingen (No. 7)

("From Melchingen, abt. 20 km. south of Tübingen." "Branco, 1898. Pl. II, fig. 1 and I, 6"). "Lower M_3" [?]

Crown only; no dentine; probably tooth from a socket before dentine was formed. Beautifully preserved, color bluish and whitish, shiny. No trace of wear.

A very remarkable tooth, showing close human affinities and widely separated by its size, which nevertheless shows nothing abnormal, from all the rest of the Bohnerz teeth.

Cusps 2 large anteriorly, 1 large labial and 1 very small lingual in the middle, and 2 moderate posteriorly. Tapering backwards in posterior third present but less evident than in the other Bohnerz teeth.

Marked precuspidal as well as postcuspidal fossa.

This tooth is so much larger than any other in the series and so near to some human teeth in the height of the enamel as well as the detailed features of the crown, that it deserves a most careful restudy and re-identification. It is a specimen of great value.

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[8] Breadth at anterior cusp 9.4; behind median cusp 8.5.
[9] Equal anteriorly and posteriorly.

MEASUREMENTS

Length, 13.2 mm.
Breadth max., 11mm.
Crown index, *83.3*
Max. height of crown labially, 4.5 mm.
Max. height of crown lingually, 4.– mm.

Dryopithecus suevicus (*rhen.*) Koken, in Tübingen (No. 6)

("From Trochtelfingen, about 30 km. south of Tübingen." "Branco, 1898, Pl. II, 6") "Left lower M_2 or M_3" [?]

Crown only, finely preserved, filled with altered dentine. Morphologically differs very perceptibly from the preceding (No. 7). Looks very much like a posterior human milk premolar.

Cusps 5, 2 anterior, 1 middle labial, 2 posterior. The anterior labial cusp is the largest and highest of all. No trace of any wear. Diminishes in breadth slightly from before backwards. Precuspidal (large) as well as postcuspidal (small) fossa present.

MEASUREMENTS

Length, 11.1 mm.
Breadth max. 9.5 mm.[1]
Crown index, *85.6*
Height max. of crown anteriorly, 5.2 mm.
Height min. of crown posteriorly 4.3 mm.

The identification of this tooth also is seriously in question, and that both as to which tooth and of what genus.

Dryopithecus suevicus Koken (*rhen.*) in Tübingen (No. 5).
"Melchingen." "Lower right M_2" [?]

Crown only. State of preservation as in all other teeth of the series. Lingually anterior fourth partly lost. Had evidently 5 cusps, 2 fairly large anterior, 1 similar labial middle and 2 somewhat smaller posterior. The cusps show slight wear. The whole crown again bears considerable resemblance to that of a posterior human milk premolar. The posterior third shows some tapering backward. There are a small precuspidal and a faint postcuspidal fossa. The identification of this tooth also needs a careful revision.

Measurements: Length, 10.7 mm.; Breadth max. about 8.9 mm.; Crown index, *83.2*.

Dryopithecus suevicus Koken (*rhen.*), in Tübingen (No. 4)
("Melchingen. Branco, 1898, Pl. II, 4"). "Lower right M_1".

Crown only, and but enamel, no dentine. Preservation as in other teeth of the series. In form resembles a 4-cusped (with a trace of 5th) right lower molar. The anterior lingual and posterior labial cusps, especially the former, are higher than the anterior labial and posterior lingual.

Anterior precuspidal fossa well marked, posterior undifferentiated from large median. There is no tapering backward in this tooth.

MEASUREMENTS

Length, 9.7 mm.
Breadth max., 9.2 mm.
Crown index, *94.8*.
Max. height of crown, labially, 4 mm.
Max height of crown lingually, 4 mm.

Resumé of Main Measurements of the Suabian Alb Bohnerz Lower Molars

	Length	Breadth	Crown Index
"Anthropodus Brancoi" (Tübingen)	10.8	8.–	*74.1*
"Dryopithecus Fontani" (Stuttgart)	10.9	8.9	*81.7*
"Dryopithecus sp." (Stuttgart)	12.–	9.8	*81.7*
"Dryopithecus rhenanus (Stuttgart)	9.4	7.–	*75.5*
"Dryopithecus suevicus (rhen.)" (Tübingen No. 7)	13.2	11.–	*83.3*
"Dryopithecus suevicus (rhen.)" (" " 6)	11.1	9.5	*85.6*
"Dryopithecus suevicus (rhen.)" (" " 5)	10.7	8.9	*83.2*
"Dryopithecus suevicus (rhen.)" (" " 4)	9.7	9.2	*94.8*

The above measurements indicate a heterogeneous lot as to teeth, and probably also as to species or even genera. They represent large forms of Primates, in instances very close to man, if not actually early human. The crown indices with one exception are low, subhuman (see further), though a few approach some of the teeth of early man (Ehringsdorf, some Předmost). One and possibly more of the low indices may however be due to the fact that the teeth are milk molars which in general are relatively narrower and hence give a lower index than the permanent lower molars.

UPPER MOLARS

In addition to the above the series of Bohnerz teeth at Tübingen comprises two large upper M_1 or M_2, one whole (No. 3) and one unerupted crown (No. 2). They are both from Melchingen and both have been attributed to *Dryopithecus rhenanus* (Schlosser, Pl. I, figs. 2, 3). These teeth are fully the size of human and resemble human teeth in form. They also resemble however and that even somewhat closer the upper M_1 and M_2 of the Chimpanzee. They measure each approximately 10.6 in median length and 11 mm. in maximum breadth and proceed from the opposite sides of two closely related individuals. If they belong to a form of fossil apes, these apes possessed denture closely related to that of man. As with the other Bohnerz teeth, though, there is an urgent need of a thorough restudy of these teeth by experts on the teeth of man as well as of the anthropoids. They need in particular extensive comparisons with immature human and ape molars.

It is strange that specimens of such an apparent age, value and great interest as the Bohnerz teeth should have received so little attention during the last decades; and that nothing should ever have been done in the line of scientific exploration of the deposits from which they came.

II. THE TEETH OF EARLY MAN

Size. As shown in a previous communication on this subject[10], the module $\frac{\text{(Length + Breadth)}}{2}$ of the lower M_1 and M_2 (the M_3 being too irregular to measure) in present man ranges as follows:

	M_1		M_2	
	Male	Female	Male	Female
Whites	10.53	10.46	10.32	10.07
Negroes	11.03	10.69	10.77	10.57
Eskimo	11.13	10.99	10.95	10.63
Melanesians	11.24	11.15	10.84	10.41
Indians	11.28	10.78	10.93	10.30

Compared to the above the lower molars of early man give these values:

SIZE OF LOWER MOLARS IN EARLY MAN

	M_1			M_2			M_3		
	Length (mean of r. & l.)	Breadth	Crown Module	Length	Breadth	Crown Module	Length	Breadth	Crown Module
Piltdown	12.–	11.–	*11.50*	12.30	11.20	*11.75*	—	—	—
Mauer	11.20	11.20	*11.20*	11.75	11.–	*11.37*	r.11.75	11.–	*11.50*
Ehringsdorf adult	11.45	11.–	*11.23*	12.10	10.65	*11.37*	11.70	9.5	*10.60*
Ehringsdorf child	11.90	10.50	*11.20*	12.50	10.80	*11.65*	—	—	—
Le Moustier	12.10	11.35	*11.73*	12.75	11.30	*12.02*	12.90	11.70	*12.30*
Spy No. 1	11.35	11.75	*11.55*	11.35	11.5	*11.43*	11.80	11.75	*11.77*
Spy No. 2	11.–	11.–	*11.–*	11.–	11.–	*11.–*	10.60	10.8	*10.70*
Krapina (both sexes)				(7 teeth)			(7 teeth)		
(mean of 12 teeth)	12.04	11.33	*11.68*	12.07	11.04	*11.56*	12.01	10.96	*11.48*
Předmost (both sexes;				(12 teeth)			(5 teeth)		
18 teeth)	11.81	10.72	*11.26*	11.18	10.70	*10.94*	11.66	10.86	*11.26*
H. aurignac. (Berlin)	11.70	11.40	*11.55*	11.40	11.35	*11.38*	10.10	10.60	*10.35*

The size of the teeth in early man is seen from the above to be in general larger than that of even the most macrodont groups of man of to-day. If it is borne in mind that two of the groups of early teeth (Krapina, Předmost) comprise those of both males and females, the latter of which lower the averages, it may be said that with the exception of very few individual specimens all the teeth of early man are larger than those of any known group of man of to-day.

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[10] This Journal, 1923, VI, No. 4, 423-438.

There is however no regular, though there is some, correlation between the size of the teeth and the antiquity of the remains. The largest teeth are those of the Mousterian youth, followed in the order named by the Krapina man; the dawn-man of Piltdown; those of the Mauer jaw; some of the Předmost teeth;[11] those of Ehringsdorf; those of Spy No. 1; and those of *H. aurignacensis* (Berlin); while the smallest are those of Spy No. 2 and some of the Předmost molars. The largest individual teeth found were the left M_1 of Krapina jaws C (13.1 x 12.1 mm.) and D (13.- x 12.-); the right M_2 of the jaw of Mauer (12.8 x 12.-); and the right M_3 of Le Moustier (13.- x 12.-); as well as a loose Krapina tooth (13.- x 12.-). Notwithstanding these irregularities in individuals and forms of early man the indications given by the above facts are that they are all derived from decidedly macrodont predecessors; that man's precursors were in all probability also highly macrodont; and that a gradual reduction in tooth size has taken place during man's progress, becoming now most marked in the more civilized parts of the white race.

Relative Proportions: The relative proportions of the lower molars are readily expressed by the Crown Index $\frac{\text{Crown breadth} \times 100}{\text{Crown length}}$. This index as was shown in the preceding parts of these studies (this Journal) decreases gradually, in general, as we proceed back in time in man, and from man to the lower Primates. The remeasurement of the teeth of early man gave values and indices which are herewith reported in detail:

Dimensions of Teeth of Early Man: Lower Molars

		LM_1			LM_2			LM_3			$LM_{1,2,3}$	
		Length[1]	Breadth[2]	Index[3]	L	B	I	L	B	I	L	I[4]
he Piltown Jaw	R.	12.–	11.–	*91.7*	12.3	11.2	*91.1*	—	—	—	—	—
	l.	12.–	11.–	*91.7*	—	—	—	—	—	—	—	*31.–*
he Mauer Jaw	r.	11.2	11.2	*100.–*	12.8	12.–	*93.7*	12.–	11.–	*91.7*	36.–	*33.3*
	l.	—	—	—	—	—	—	11.5	11.–	*95.7*	—	—
hringsdorf Adult	r.	11.2	11.–	*98.2*	12.2	10.8	*88.5*	11.7	9.5	*81.2*		
	l.	11.7	11.–	*94.–*	12.–	11.5	*95.8*	(8.–	7.7)	*(96.2)*		
Child	r.	—	—	—	—	—	—	—	—	—		
	l.	11.9	10.5	*88.2*	12.5	10.8	*86.4*					
e Moustier	r.	12.2	11.5	*94.3*	12.5	11.3	*90.4*	13.–	n.12.–	*92.3*		
	l.	12.–	11.2	*93.3*	13.–	11.3	*86.9*	n.12.8	11.4	*89.1*		

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[1] At middle, from middle of upper border of anterior to same point (or corresponding one) of ontact facet.

[2] Maximum.

[3] $\frac{\text{B x 100}}{\text{L}}$

[4] $\frac{\text{B. max. x 100}}{\text{L. of } M_{1}, {}_{2} \,\&\, {}_{3}}$

Spy, No. 1	r.	11.2	11.7	*104.7*	11.2	11.3	*100.9*	11.4	11.7	*102.6*		
	l.	11.5	11.8	*102.6*	11.5	11.7	*101.7*	12.2	11.8	*96.7*		
No. 2	r.	11.–	11.–	*100.–*	11.–	11.–	*100.–*	10.2	11.–	*107.8*		
	l.	11.–	11.–	*100.–*	11.–	11.–	*100.–*	11.–	10.6	*96.4*		
Krapina Jaws *B*	r.	—	—	—	—	—	—					
(child)	l.	11.1	10.2	*91.9*	—	—	—					
C	r.	12.9	12.1	*93.8*	—	—	—					
(child)	l.	13.1	12.1	*92.4*								
D	r.	—	—	—								
(adult or n)	l.	11.7	10.6	*90.6*								
E	r.	—	—	—	—	—	—	—	—	—		
	l.	13.–	12.–	*92.3*	12.7	11.4	*89.8*	—	—	—		
G	r.	12.–	11.2	*93.3*	12.9	11.2	*86.8*	11.5	11.–	*95.6*	36.1	*31.–*
	l.	—	—	—	—	—	—	—	—			
H	r.	12.–	11.–	*91.7*	12.–	11.2	*93.3*	12.–	11.–	*91.7*	36.–	*31.1*
	l.	11.9	10.9	*91.6*	11.9	11.1	*93.3*	12.–	10.8	90.–	35.6	*31.2*
I	r.	11.7	n.11.8	n.100.–	11.8	—	—	11.8	—	—	35.–	?
	l.	11.3	11.2	*99.1*	12.2	11.4	*93.4*	—	—	—	—	
Separate Teeth[a]	r.	12.3	12.–	*97.6*								
	r.			—	11.–	11.–	*100.–*					
	r.							12.–	11.–	*91.7*		
	r.							12.5	11.–	*88.–*		
	r.							13.–	12.–	*92.3*		
	r.							11.1	9.9	*89.2*		
	l.	11.5	10.8	*93.9*								
H. aurignacensis (Předmost)[11]												
Jaws	r.	11.8	10.1	*85.6*	11.–	10.–	*90.9*					
I	l.	11.4	10.2	*89.5*	10.1	9.9	*98.0*					
Juv. II	r.	12.2	10.9	*89.3*								
	l.	12.2	10.9	*89.3*								
III	r.	11.8	11.–	*93.2*	12.–	11.2	*93.3*	12.7	11.4	*89.8*	36.–	*31.7*
	l.	11.9	11.3	*95.–*	12.6	11.7	*92.9*	—	—	—	—	—
V	r.	12.–	10.7	*89.2*	10.8	10.6	*98.1*	—	—	—		
	l.	11.7	10.7	*91.4*	10.9	10.6	*97.2*	—	—	—		
Juv. VI	r.	—	—	—								
	l.	12.9	11.–	*85.3*								
IX	r.	12.6	11.3	*89.7*	12.2	11.7	*95.9*	12.5	n. 11.7	*93.6*		
	l.	12.5	11.–	*88.–*	12.1	11.3	*93.4*	13.–	11.2	*86.2*	36.6	*30.9*
X	r.	10.6	9.8	*92.4*	10.–	9.8	*98.–*	10.–	10.–	*100.–*	31.3	*31.9*
	l.	10.8	—	—	10.5	—	—	10.5			31.7	
XIV	r.	12.2	11.2	*91.8*	—	—	—					
	l.	11.4	10.9	*95.6*	12.–	11.6	*96.7*					
3070	r.	10.3	10.–	*97.1*	9.5	10.–	*105.3*	10.1	10.–	*99.–*	29.4	*34.–*
	l.	—	—	—	—	—	—	—	—	—	—	—
476	r.	11.5	10.5	*91.3*	—	—	—					
	l.	11.–	10.4	*94.6*	n. 11.–	10.–	*90.9*					
iuv. 259	r.	11.8	11.–	*93.2*								
	l.	—	—	—								
H. aurignacensis												
(in Berlin)	r.	11.7	11.2	*95.7*	11.3	11.2	*99.1*	9.–	10.2	*113.3*	32.3	*34.7*
	l.	11.7	11.6	*99.1*	11.5	11.5	*100.–*	11.2	11.–	*98.2*	32.5	*35.7*

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[a] Identification not always absolutely certain.

[11] Middle to upper Aurignacian.

MOLAR INDICES $\frac{\text{BREADTH MAX x 100}}{\text{MEDIAN LENGTH}}$ ARRANGED CONSECUTIVELY

ocality	M$_1$ L.B. Index	Locality	M$_2$ L.B. Index	Locality	M$_3$ L.B. Index	All 3 Locality	Index
ředmost VI	85.3	Ehringsdorf,,child	86.4	Ehringsdorf, r. ad.	81.2	Předmost, IX, 1.	30.9
" I r.	85.6	Krapina *G*	86.8	Předmost, IX, 1.	86.2	*Piltdown, r, near*	*31.–*
" IX 1.	88.–	Le Moustier, 1.	86.9	Krapina, sep. t.,	88.–	Krapina, *G*,	31.–
hringsdorf, child	88.2	Ehringsdorf, ad. r	88.5	Le Moustier, 1.	89.1	" *H*, r.	31.1
ředmost, V, r.	89.2	Krapina, *E*,	89.8	Krapina, sep. t.	89.2	" *H*. 1.	31.2
" II, r., 1.	89.3	LeMoustier, r.	90.4	Předmost, III.r.	89.8	Předmost, III,r.	31.7
" I, 1.	89.5	Předmost, I, r.	90.9	Krapina, *H*, 1.	90.–	Krapina X, r.	31.9
" IX, r.	89.7	Predmost No. 476	90.9	" *H*, r.	91.7	Mauer, r.	33.3
rapina, *D*,	90.6	*Piltdown*	*91.1*	Mauer, r.	91.7	Předmost. No. 3070	34.–
ředmost No. 476	91.3	Předmost, III, 1.	92.9	Krapina, sep. t.	91.7	H. Aurignac. (Berlin) r.	34.7
" V, 1.	91.4	" III, r.	93.3	LeMoustier, r.	92.3	H. Aurignac. (Berlin) 1.	35.7
rapina, *H*. 1.	91.6	Krapina, *H*, r., 1.	93.3	Krapina, sep. t.	92.3		
iltdown, r., l.	*91.7*	,, *I*	93.4	Předmost, IX, r.	93.6		
rapina *H*, r.	91.7	Předmost, IX, 1.	93.4	Krapina, *G*,	95.6		
ředmost, XIV, r.	91.8	Mauer	93.7	Mauer, 1.	95.7		
rapina, *B*,	91.9	Ehringsdorf, ad. 1.	95.8	Spy, II, 1.	96.4		
" *E*	92.3	Předmost, IX, r.	95.9	" I, 1.	96.7		
" *C*, 1.	92.4	" XIV	96.7	H. Aurignac. (Berlin), 1.	98.2		
ředmost, X,	92.4	" I, r.	97.1	Předmost, 3070	99.–		
" 259	93.2	" V, 1.	97.2	" X	100.–		
" III, r.	93.2	" X, r.	98.–	Spy, I, r.	102.6		
e Moustier, 1.	93.3	" V, r.	98.1	Spy, II, r.	107.8		
Krapina, *G*	93.3	H. aurignac. (Berlin), r.	99.1	H. aurignac. r.	113.3		
" *C*, r.	93.8	" 1.	100.–				
" veps. tooth	93.9	Krapina, sep. t.	100.–				
Ehringsdorf ad. r.	94.–	Spy, II, r., 1.	100.–				
Le Moustier, r.	94.3	" I, r.	100.9				
Předmost No. 476	94.6	" I, 1.	101.7				
" III, 1.	95.–	Předmost, No. 3070	105.3				
" XIV	95.6						
H. aurignac. (Berl.) r.	95.7						
Předmost, 3070	97.1						
Krapina, sep. t.	97.6						
Ehringsdorf, ad. r.	98.2						
Krapina, I, 1.	99.1						
H. aurig. Berl. 1.,	99.1						
Mauer	100.–						
Spy, II, r., 1.	100.–						
Krapina, I, r.	100.–						
Spy, I, 1.	102.6						
" , I, r.	104.7						

The principal points brought out by the above data may briefly be enumerated as follows:

1. As in absolute so in relative size the lower molars bear a general definite correlation with time: the greater their antiquity the greater the relative length of the teeth and *vice versa.*
2. The breadth (or stoutness) of the tooth in the course of man's existence has shown but little change, much less than the length.
3. The facts indicate that in man's precursors the lower molars were longer but probably only slightly stouter than they are in man of to-day.
4. Taking the lower molars in present man, it is safe to regard as primitive or phylogenetically inferior a tooth that is absolutely large, or one that is relatively long so as to give a low crown index.

The progressive shortening of the human lower molars must have been concomitant, it is plain, with a progressive shortening of the jaws, though the change was evidently in the teeth and not in the jaws; had it been in the latter there would in all likelihood be observable a compensatory increase in the breadth (stoutness) of the teeth and the M_3 would be least affected, which is not the case.

M_3.—Some additional observations of interest were possible on the M_3 in the remains of early man. With very few exceptions this tooth shows no degeneracy or alteration such as are common in modern man. As may be seen in the table on the "Size of the lower molars in early man" (p.——) there is a progression in the size of the teeth from before backward in the jaw of Piltdown, though in this case we have only the more anterior two molars; in the jaw of Mauer, where the M_2 is larger than M_1 and M_3 larger than M_2; in both the jaws of Ehringsdorf, where M_2 is larger than M_1, though in the adult the M_3 is smaller than either of the preceding teeth; and in the Mousterian youth, where we have a decided progression in the size of the three molars from before backwards. In all the rest of the teeth, M_2 averages slightly less than the M_1, and the M_3 is smaller than the M_2, except in the Předmost teeth where the M_3 is larger than the M_2, equalling M_1. Individually, a progression from before backwards in the size of the three molars was observed in the Předmost jaw No. 3, while in jaw No. 9 from the same locality the progression on the right is M_1, M_2, M_3 (the M_3 being the largest) while on the left it is M_2, M_1, M_3. We see thus that in early man, the ancient condition of the molars progressing in size from before backwards is still more or less in evidence in the older forms, disappearing more and more as recent times are approached.

III. THE PRECUSPIDAL AND POSTCUSPIDAL FOSSAE[12]

The pre- and postcuspidal fossae, mentioned in other parts of this paper, deserve special consideration.

An extended study of the various detailed features of the masticatory surface of the crowns of human teeth, shows that all these features, including the seemingly insignificant ridges and depressions, have a definite meaning and connect with conditions in some cases better represented, in others perhaps only barely indicated, in the corresponding teeth of lower Primates and even other mammals. The crown of the human tooth even in its minute details presents but little that is fortuitous. It is the resultant of inherited ancestral conditions, modifying further by evolution and involution. The pre- and the postcuspidal fossa are two features developed by those agencies.

The precuspidal fossa in its typical form is a rather marked isolated depression in the enamel, lying transversely between the anterior free border of the crown and a line connecting the bases of the two fore cusps; while the postcuspidal fossa is a similar depression located in the enamel between the line of the two hind cusps of a molar and the posterior free border of the crown.

In different lower molars the fossae differ much in both shape and size. They vary from a short, often darker colored, ramifying, faintly depressed line or a dotlike concavity, to a strong groove, or a large, deep, wedge-shaped, oval or rounded fossa. One or both of the fossae may be completely isolated, or communicate by a line, groove or even a channel with the crucial depression amidst the four cusps.

When a large number of human and other Primate jaws are examined, it is seen that these pre- and postcuspidal fossae are not limited to the lower molars but are at times well represented also on the upper molars and on the permanent lower premolars, while modifications or traces of them may occasionally be seen even on the canines, the upper premolars and the incisors, connecting in the latter with the "shovel-shaped" character.[13] Sufficient comparative studies, finally, clear the significance of the two frequently so characteristic depressions. They are found to be homologous remnants of two larger depressions which in earlier stages of the molars occupied most of the masticatory surface of the crown. The formation of the pre- and postcuspidal

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[12] So named for convenience by the writer. Just before this paper had gone to "print, Dr. Milo Hellman has called the writer's attention to Adolf Remanés report, Beiträge zur Morphologie des Anthropoidengebisse," published in Berlin, in which one or both of these fossae are mentioned.

[13] See this Journal, 1920, III, 429 *et seq.*

Upper Figure

Mandible of adult male Alouatta vil. (61,282, U.S.N.N.) showing development of pre- and postcuspidal fossa. (Enlarged)

Lower Figure

Uppermost tooth—Lower molar attributed to *Dryopithecus rhenanus.* (No.7, Geolog.—Palaeontol. Inst. Tübingen), showing a well-marked precuspidal as postcuspidal fossa.

Upper row, left to right—right lower M_1,[1]) with a postcuspidal fossa; r.l. M_2, with a precuspidal fossa; r.l. M_3 with a precuspidal fossa.

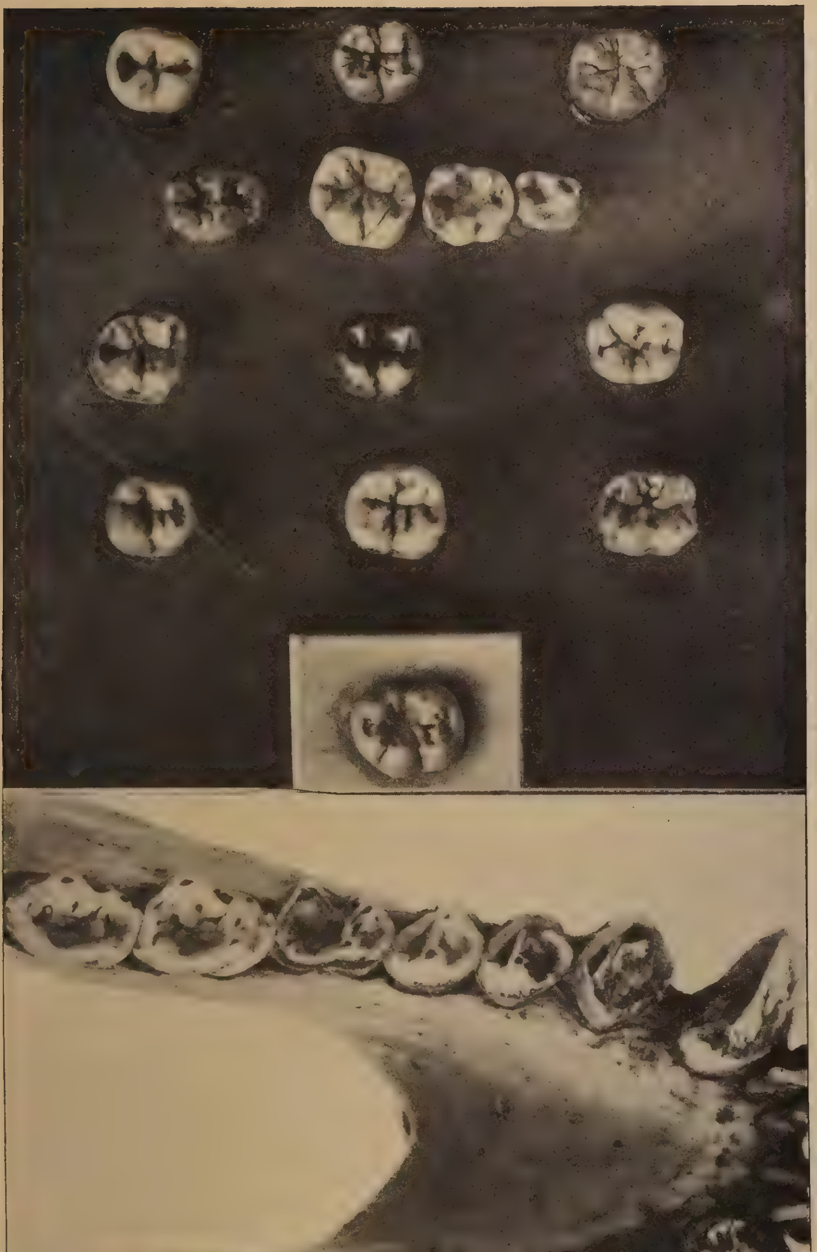
Second row from above, left to right—l.l.M_1, with a small pre- and a small postcuspidal fossa; r.l. M_3, with marked pre- as well as postcuspidal fossa; r.l.M_3 with a marked precuspidal and and shallow postcuspidal fossa.

Second row from below, left to right—the right lower milk premolars and perm. M_1 of an Indian child; r.l.M_3, with a marked precuspidal and a marked primary postcuspidal fossa.

Lowest row, left to right—r.l.M_1—with no trace of fossae; r.l. M_2, with both fossae; r.l. M_1, with a small precuspidal and a large postcuspidal fossa.

(All slightly enlarged)

[1] Teeth all extracted from jaws, so that identification is reliable.



fossa as shown by the teeth from lemurs to man, and in other phyla, may be outlined as follows:

The primordial form of the crown of or antedating the Primate teeth and probably that in or preceding other mammals, does not in the writer's studies appear to have been "bicuspid" or "dimer," or "triconodont" or even monocusp, but rather a simple conical peg not unlike (though perhaps not related to) the present teeth of the Pinnipedia. The masticatory surface of the crown it would seem was smooth, its border even. No actual example of such a crown has yet been found. The next morphological stage however is one of which the lower Primates occasionally still show good vestiges. It was the beginning of a development from the border enamel of such a crown of one (labial) or two opposed (labial-lingual) small projections, the rudimentary serrations that were to become cusps. At the same time the rest of the border by increase in the enamel was being raised into a rim about the masticatory crown surface, resulting in a central depression.

The process continuing, the single or double primitive first cusps enlarged to conical elevations, and as they did so the mesial part of their base or bases growing stouter extended gradually across the crown depression. In the case of a single cusp, the elevation of its base would result in the separation of the surface depression of the crown into an anterior and posterior portion—condition plain evidence of which we can actually still see on numerous canines as well as some incisors of man, anthropoid apes and lower monkeys. Where two opposed cusps were developing, their mesial bases eventually coalesced and the line of coalescence separated the original crown depression into a smaller anterior and larger posterior portion. The anterior portion, in various stages of preservation or involution, is the precuspidal fossa of the present day teeth; while the posterior portion became the primary postcuspidal fossa, such as is still preserved in numerous Primate premolars and even some molars. Subsequently, and this may be followed on numerous examples in the teeth of the lower Primates, there are seen developing from the border of the crown two additional more posterior opposed cusps, and the growth of these repeats in the primary postcuspidal fossa what the first pair of cusps wrought on the crown fossa as a whole: they gradually divide the depression into two, the anterior part now becoming the central or crucial depression in the crown of the molar while the posterior part, as a rule smaller, remains as a secondary postcuspidal fossa, such as—again in various stages of preservation or disappearance—may still be seen in many Primate including some human lower molars. Wherever the mesial fusion of the bases of the anterior or posterior part of cusps has remained incomplete, there is found a channel or a groove connecting the pre- or postcuspidal fossa with the central depression. Where a fifth cusp has developed from the rearmost portion of the enamel border of a lower molar, as is general in the Old World monkeys, there the postcuspidal fossa is enclosed by the posterior pair and the fifth cusp. Where a fifth cusp has developed laterally (or assumed lateral, labial position) there the fossa is hindmost, though generally displaced somewhat lingually.

Where on the teeth the enamel has become more or less worn off, which is very common, particularly on M_1 and M_2, one or both fossae have disappeared or been reduced to mere traces. Where the posterior part of the crown with its cusps has not been sufficiently differentiated, as in the *Cebidae* and other of the smaller American monkeys, there still exists in most cases only the primary postcuspidal fossa; but if there is a specimen among these species in which the posterior cusps are well differentiated then there is at once a well marked median with a distinct postcuspidal fossa. Where, as especially in human teeth, the enamel at the base of the cusps has grown more abundant, there the fossae have been encroached upon until frequently the precuspidal fossa has been so compressed that it shows merely the wrinkled line of its closed lips, while the postcuspidal fossa has been reduced to a mere trace, or as in modern man has with rare individual exceptions completely disappeared.

The presence in human lower molars of a well marked precuspidal fossa or especially of a more or less well preserved postcuspidal one, or both, is in view of all that has been learned to be regarded as a primitive feature reflecting earlier phases of evolution. The presence of a well marked postcuspidal fossa in earlier human teeth tends to connect these directly with those of anthropoid apes and other sub-human Primates.

Among the races of man of to-day the more primitive conditions in respect to the pre- and postcuspidal fossae are strangely enough not found among the primitive races, but in the whites. The peculiar showing of the whites in this and some other respects is possibly connected with their present variability, which appears to have become increased by the conditions of modern life. The only other explanation would be that the whites represent a strain which preserves this and other reminiscences of earlier stages more than the other now living strains of the human family.

There are rare instances in which a human molar or premolar, permanent or deciduous, shows still such a poor development of the cusps that the anterior middle and posterior fossae are broadly united forming but one irregular depression. This is of course an inferior condition.

The posterior and to a smaller extent (perhaps due to pressure on the preceding tooth) also the anterior, remnant of the border of the crown, not yet utilized for the development of cusps, remains capable of developing further cusps. Of these there may be one to three posteriorly and possibly one anteriorly. When the crown margin has thus been fully utilized further cusps may still develop from the "cingulum" (*q. v.*)

Teeth of fossil forms of Primates, such as studied by Ameghino, Wortman, Gregory and Gidley, appear to be teeth already well differentiated and cannot be considered as prototypes of more recent Primates. The "primitive trigone" theory based upon these and other teeth will need it seems, in view of the above facts, a reconsideration.

RÉSUMÉ

The evidence of *Primate* teeth (lemurs to man) in connection with the features dealt with in these pages points to the fact that these teeth are simple and not composed of two or more originally separate elements; that they may have developed neither from a polycone nor a bicuspid, but that the underlying form was more probably a convex or a flat-top simple crown; that, on functional demands, all cusps developed from the margin of the enamel about the surface of the crown; that in the lower molars they developed in the order: *ae* and *ai*—which became the first pair—then *pe* and *pi*, the second or hind pair, and then one to several still more posterior; that these cusps do not represent and are not derived from a fundamental "trigon" but that a "trigon" in any ancient or modern tooth is rather to be viewed as a differentiation; that the fossae left before, between and behind the cusps are the remnants of the primordial surface of the tooth left in depression by the elevation of the enamel of the rim and the cusps and the confluence of the latter; and that the disappearance of the fossae (more or less) is due to the spread of the enamel over the surface of the crown.

PRE- AND POSTCUSPIDAL FOSSA IN LOWER PRIMATES

Tarsii: Nothing distinct.

Lemurs (24): In all a generally marked precuspidal, *no* vestige of a postcuspidal fossa. The precuspidal is not of the classic form (apes and man) and not easy to recognize, especially in some forms, without much work on other teeth (best marked in a *Lemur macac.* also *Hapalemus griscus* and a *Lemur sp.* from Malaysia). Imperfect condition of cusps throws good light on how fossae are formed.

Tardigradus: Distinct precuspidal fossa on all lower molars ("a-b"), postcuspidal on none.

Propithecus (8): Conditions in this form not well defined. Traces more or less plain of anterior and occasionally seemingly even posterior fossa.

Nycticebus (16): Distinct precuspidal fossa on all lower molars ("a-b"), postcuspidal on none.

Periodictus ibeanus: Traces ("tr-a") of precuspidal fossa on all teeth that are not worn. No postcuspidal.

Galago (20): Mostly nothing distinct, but plain precuspidal fossa ("tr-a"). Example—*G. allem.* 101, 515; also on *G. lasiotis pang.*, 35, 093 and on some other larger ones.[14] No postcuspidal fossa on any.

Smaller American monkeys: Conditions closely allied to those in *Cebus* and *Ateles*—nothing very special. Anterior fossa in all well marked, posterior represented by the middle, or but traces.

Ateles (10): Both fossae finely developed on all three premolars; on molars only anterior with traces (rare) of posterior—the posterior cusps are still parts of the margin of the crown and not sufficiently isolated. When better differentiated the basal sulcus connecting middle with posterior fossa appears (*e. g.* 194, 340). In 194,338 there is a smaller anterior and larger posterior fossa—as in some *Alouatta*.

Cebus (10): Much the same as in *Ateles*.

Alouatta (10): Both fossae very well marked on all three premolars; on molars only anterior; posterior is still in most species the middle, the hinder cusps not joining at all but tending to,—a primitive condition. In one (61,282) even the anterior cusps do not join and there is an hourglass concavity. Where posterior cusps do not join at base there are three distinct fossae—a, m and p (*e. g.* 22,833, M_3).

Erythrocebus patas, 1 male: Pre- as well as postcuspidal fossa small but well marked on all lower molars, both even better developed on upper molars and premolars.

Cynopitheci (6): The two fossae are observable on all the lower teeth up to and including the canines; least marked on M_1, most on M_3.

Magus (10): Same as in *Cynopitheci*. Both fossae in all, though often poorly marked due to wear of enamel.

Macaques; *Pitheci:* In both of these forms which show closely re-

[14] On all *G. lasiotis lasiotis*; nice on *G. Kikuyuensis.*

lated teeth, but especially in the *Pitheci*, each of the lower molars has when unworn a small to good-sized pre- as well as postcuspidal fossa. Fossae smallest on M_1, largest on five-cusped M_3. (On M_1 also least noticeable due to earliest wear. Even slight wear effaces the fossae more or less).

Cercocebi (10 both sexes): Both pre- and postcuspidal fossae present and well developed though not large, on all unworn lower molars.

Colobus (36): In all lower molars slight to large ("a-c") precuspidal and moderate ("1") to large ("3") postcuspidal fossa. In M_3 condition more or less obscured by the fifth cusp.

Nasalis (10) All:		M_1	M_2	M_3	M_1	M_2	M_3
No. of teeth examined		20	19	18	*Per cent*		
Precuspidal fossa	—	0	0	0	—	—	—
	tr	14	15	13	*70*	*79*	*72.2*
	a	4	3	4	*20*	*15.8*	*22.2*
	b	2	1	1	*10*	*5.2*	*5.6*
Postcuspidal fossa:	—	5	1	8	*25*	*5.2*	*44.5*
	x	8	11	2	*40*	*57.9*	*11.1*
	1	6	4	—	*30*	*21.1*	—
	2	1	3	8	*5*	*15.8*	*44.5*

Teeth generally slightly worn, so that original condition more or less lost. On all lower molars traces of both anterior and posterior fossa which were probably all small to moderate fossae to start with. On M_3 a large posterior fossa. This tooth is prolonged backward to a fifth cusp (M_1 and M_2 always four cusps). The fifth is not yet a definite cusp but only an elevated rim and in front of it and behind the last two cusps exists a large fossa corresponding to location of and homologous with the postcuspidal fossa on M_1 and M_2.

Presbytis (123): "a" (most) to "b", and "1" to "3" on all (mostly "1"; largest on M_3).

That the fossa before the 5th cusp is the postcuspidal may be seen on specimens on which this cusp is not or but slightly developed.

Theropithecus, 1 female: On each M_1 a trace of precuspidal; on each M_2 a small pre- and a small postcuspidal; and on each M_3 a trace of postcuspidal fossa.

Baboons (21 mandibles, both sexes): Where teeth are not worn both pre- and postcuspidal fossa is present as a rule; the latter being at times *very marked* in M_3. Both fossae are also present on each of the premolars. At times there is a curious arrangement of things on PM_1 or a nice demonstration of the formation of the fossae on PM_2.

THE PRE- AND POSTCUSPIDAL FOSSA IN ANTHROPOID APES

		Males			Females		
		LM$_1$	M$_2$	M$_3$	M$_1$	M$_2$	M$_3$
Number of molars examined:	Gibbons and Symphalangi	64	64	55	63	62	52
	Orangs	46	41	39	57	47	34
	Gorillas[1]	17	15	14			
	Chimpanzees[1]	29	21	13			
PRECUSPIDAL FOSSA:							
Absent (or very nearly so):	Gibbons, *per cent*	1.6	6.2	28.2	1.6	8.1	19.2
	Orangs	8.7	19.5	38.5	1.8	2.1	17.7
	Gorillas	—	—	—			
	Chimpanzees	—	—	—			
Plain trace ("tr")	Gibbons	31.2	20.3	38.2	12.7	9.7	28.8
	Orangs	76.1	65.9	51.3	75.4	61.7	47.1
	Gorillas	58.8	60.–	57.2			
	Chimpanzees	41.4	38.1	38.5			
Small well formed fossa ("a")	Gibbons	56.2	46.9	25.5	68.3	53.2	46.2
	Orangs	15.9	14.6	10.3	17.5	34.–	35.3
	Gorillas	41.2	26.7	21.4			
	Chimpanzees	37.9	23.8	23.–			
Larger fossa ("b")	Gibbons	10.9	26.6	9.1	17.5	29.–	5.8
	Orangs	—	—	—	5.3	2.1	—
	Gorillas	—	13.3	21.4			
	Chimpanzees	20.7	38.1	38.5			
POSTCUSPIDAL FOSSA:							
Absent (or very nearly so)	Gibbons	75.–	79.7	93.1	76.2	58.1	90.4
	Orangs	47.8	43.9	94.9	57.9	63.9	88.2
	Gorillas	5.9	13.3	7.1			
	Chimpanzees	41.4	42.9	77.–			
Plain trace ("x")	Gibbons	21.9	10.9	7.3	14.3	24.2	5.8
	Orangs	52.2	53.7	5.1	35.1	34.–	11.8
	Gorillas	58.8	60.–	28.6			
	Chimpanzees	34.5	38.1	23.–			
Small well formed fossa ("1")	Gibbons	3.1	9.4	1.8	9.5	17.7	3.8
	Orangs	—	2.4	—	3.5	2.1	—
	Gorillas	29.4	13.3	42.8			
	Chimpanzees	24.1	9.5	—			
Larger fossa ("2")	Gibbons	—	—	—	—	—	—
	Orangs	—	—	—	3.5	—	—
	Gorillas	5.9	13.3	21.4			
	Chimpanzees	—	9.5	—			

[1] Both sexes

PRE- AND POSTCUSPIDAL FOSSAE IN LOWER MOLARS OF EARLY MAN

	M$_1$	M$_2$	M$_3$
Precuspidal Fossa:			
Piltdown	worn	worn	
Mauer	worn	worn	worn
Spy	worn	worn	worn
H. mousteriensis	well developed both sides	well developed both sides	well developed both sides
Krapina	(12 teeth) plain trace to well developed in all	(9 teeth) moderate to marked in all	(7 teeth) moderate to marked in all
H. aurignacensis (Berlin)	present (some wear)	present (some wear)	present

	M.	M.	M.
Předmost	(17 teeth) apparently absent in 12 (in some wear may account for seeming absence) plain trace to small fossa in 5.	(19 teeth) apparently absent in 3 moderate to marked in 16.	(15 teeth) absent in 5 moderate to well marked in 10.
Postcuspidal Fossa:			
Piltdown	worn	worn	worn
Mauer	worn	worn	worn
Spy	worn	worn	worn
H. mousteriensis	none	none	none
Krapina	(12 teeth) absent in 11 small in 1.	(9 teeth) absent in all	(7 teeth) absent in all
H. aurignacensis (Berlin)	? (wear)	?	absent
Předmost	absent in 13 small, in 2 marked, in 2	absent in all	absent in all

INCIDENCE OF PRE- AND POSTCUSPIDAL FOSSAE IN MAN OF TO-DAY

		Males			Females		
		LM_1	M_2	M_3	M_1	M_2	M_3
NUMBER OF TEETH EXAMINED[15]							
	Malanesians[16]	22	23	27			
	Negroes[16]	23	27	26			
	Eskimo[16]	39	38	34			
	Indians[16]	26	71	132			
	Indian children[16]	151	52	—			
	Whites (American, miscell.)	83	126	98	72	107	100
PRECUSPIDAL FOSSA:							
Absent (or very nearly so)	Melanesians, *per cent*	72.8	34.8	70.4			
	Negroes	17.4	11.1	38.5			
	Eskimo	59.	47.4	41.2			
	Indians	38.5	19.7	61.4			
	Indian children[17]	33.8	19.2				
	Whites	55.4	15.1	30.6	47.2	19.6	29.-
Plain trace ("tr")	Melanesians	22.7	34.8	11.1			
	Negroes	34.8	44.4	30.8			
	Eskimo	30.8	28.9	29.4			
	Indians	53.8	40.8	27.3			
	Indian children	43.7	23.1				
	Whites	28.9	20.6	23.5	26.4	17.8	26.-
Small but well formed ("a")	Melanesians	4.5	30.5	18.5			
	Negroes	43.5	37.-	23.1			
	Eskimo	10.3	23.7	29.4			
	Indians	7.7	36.6	11.4			
	Indian children	15.9	44.2	—			
	Whites	16.9	57.9	37.8	26.4	51.4	30.-
Larger fossa, well formed ("b")	Melanesians	—	—	—			
	Negroes	4.3	7.4	7.7			
	Eskimo	—	—	—			
	Indians	—	2.8	—			
	Indian children	6.6	13.5				
	Whites	—	6.3	9.2	—	11.2	16.-

		Males			Females		
		LM.	M.	M.	N.	M.	M.
Postcuspidal Fossa:							
Absent (or very nearly so)	Melanesians	100	100	92.6			
	Negroes	95.7	88.9	57.8			
	Eskimo	97.4	97.4	97.1			
	Indians	100.	97.2	96.2			
	Indian children	98.7	94.2				
	Whites	92.8	92.9	83.7	81.9	80.4	84.–
Plain trace ("x")	Melanesians	—	—	3.7			
	Negroes	4.3	11.1	34.6			
	Eskimo	2.6	2.6	2.9			
	Indians	—	2.8	2.3			
	Indian children	1.3	5.8				
	Whites	4.8	6.3	11.2	15.3	14.–	11.–
Small but well formed ("1")	Melanesians	—	—	3.7			
	Negroes	—	—	7.6			
	Eskimo	—	—	—			
	Indians	—	—	1.5			
	Indian children	—	—				
	Whites	2.4	0.8	4.1	2.8	5.6	4.–
Good sized fossd ("2")	Melanesians	—	—	—			
	Negroes	—	—	—			
	Eskimo	—	—	—			
	Indians	—	—	—			
	Indian children	—	—				
	Whites	—	—	1.–	—	—	1.–

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[15] All teeth showing wear were excluded; the greatest trouble due to this cause was met with, particularly with M, in the Indians and Eskimo. In whites the number of individuals represented is much larger than the numbers would seem to indicate, as many teeth were missing or decayed.

[16] The number of teeth in these series being smaller and the sexual differences very irregular, the males and females are joined.

[17] The frequency of the fossae in Indian child and Indian adults is much the same; differences in their nature may partly be due to the fact that the two series differ somewhat as to tribes, and partly to slight wear in the utilized teeth of the adults.

IV. THE CINGULUM[18]

In the course of the studies reported here it was found possible to make further observations on the question of just what is the cingulum; and the only conclusions that it seemed possible to reach are as follows:

The formative part of the teeth so far as the differentiation of the masticatory surface of the crown is concerned, is the margin of the enamel surrounding the crown (or its parts, as in some lower forms). It is from this margin that the various cusps (or their equivalents) are developed, and it is the further development of the cusps which gives the detailed features of the crown.

Before the development of the cusps (or their equivalents) there is no "cingulum" and none is needed. In teeth in which the functional demands are not in excess of the potentialities of the crown as formed by the cusps, or in which these calls are gradually diminishing, as in general in civilized man, there again is no need for any "cingulum," none is developed and none is present unless it be by chance persistence or reversion, or special call, in individual specimens. In teeth however the demands upon which tend to exceed the possibilities of the crown as developed from the marginal enamel, there is an effort of nature to substitute or supplement the now no more available margin of the crown by circumferential redundance of the enamel about the crown, that strengthens the teeth and presents a blunt secondary margin from which the development of additional cusp or cusps is possible. The "tubercle of Carabelli" which is occasionally met with in strong human teeth, is an example of such an accessory cusp developed from a lateral strengthening of the enamel of the crown, and there are numerous such developments in lower mammals. But the lingual cusps of some human incisors and canines are probably additional developments from what remains of the original margin of the crown, which in these cases has not been fully used up for the development of cusps.

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[18] For representative modern views of the "cingulum" showing well the inperfection of present knowledge concerning the structure, see Tomes "Manual of Dental Anatomy", the 8th (1923) edition, pp. 335, 350, 407.

LITERATURE

EVOLUTION, EARLY MAN

THE AGE OF THE EARTH. No. 4, Vol. LXI, 1922, of the *Proceedings of the American Philosophical Society* brings a valuable symposium on "The Age of the Earth from the Geological Viewpoint," by T. C. Chamberlin; "The Age of the Earth from the Paleontological Viewpoint," by John M. Clarke; "The Age of the Earth from the Viewpoint of Astronomy," by Ernest W. Brown; and "The Radio-Active Point of View," by William Duane.

While of indirect interest to Physical Anthropology, these articles written by men of high calibre deserve to be carefully perused. The conclusions are very cautious, pointing rather to the great difficulties still in the way of anything like correct approximations than giving definite estimates.

THE GEOLOGICAL HISTORY OF THE PRIMATES. By Thacker (A. G.)—*Science Progress*, April, 1922, 595–607.

In this altogether too brief paper, the author shows the great importance to Anthropology of the study of the geological history of the Primates. He regards this in fact as "the necessary and logical link between mammalian palaeontology as a whole and the special and narrow subject of prehistoric anthropology." He hastens to point out, however, that such history is far from a simple and straightforward story.

The larger part of the article deals with ancient land connections which help to explain the distribution of the Primates. We can discern, the author thinks, five periods in the age of Mammals: "The first period is one of general unity, though, as already pointed out, there may never have been a point at which all the land-bridges existed absolutely contemporaneously. Then South America was separated. The second period was therefore characterized by the isolation of South America and the union of the other four continents. Then Africa was separated. In the third period therefore three enormous but distinct areas of placental evolution existed. This period was long; it corresponds to the greater part of the Eocene and most of the Oligocene of the stratigraphists. Then Africa was reunited. The fourth period therefore resembled the second in the independence of South America and the union of the other four continents. Finally South America was at last reunited, and this event ushered in the fifth and last period, an epoch of general unity; this general unity seems to have been surprisingly perfect in the Pliocene, though seriously interrupted for brief periods during the cold phases of the Pleistocene and at the present day. These separations and reunions are the outstanding events of the Cainozoic

Era. They profoundly influenced mamalian evolution. They are, it seems to me, to be regarded as literally 'epoch-making.' "

The latest lemurine fossils are found in a transition bed between the Paleocene and Eocene, while monkeys and higher apes begin to occur respectively in the Oligocene and Miocene. These are no new data. The author has merely endeavored to "show how much is clear and how much is at present uncertain in the general story of the Placentalia and to indicate the highly mysterious part in that story which is played by the higher Primates. The American monkeys are still one of the most remarkable problems in mammalian zoology. . . Another point which is of special interest to anthropologists is that, according to the indications which we possess at present, the evolution of the Catarrhina as a distinct group took place in Africa."

THE PEOPLING OF ASIA. By Hrdlička (Aleš)—*Proc. Amer. Philos. Soc.*, 1921, LX, (Feb. 1922), 535 *et seq.*

A résumé of two courses of lectures on the subject given by the author at the American University, Washington. The peopling of Asia necessarily leads to the consideration of the whole problem of the peopling of the earth. In the author's opinion the old centre of dispersion in all directions, was Western Europe. All the movements of man followed in the main three primary laws, which were: spread in the direction of least resistance; that in the direction of better prospects (food, climate, liberty, etc.); and that in the direction of force from behind. The peopling of the earth followed evidently in the order of: Europe; Africa and western Asia; southern Asia, and the rest of that continent, with part of Oceania; America; and eastern Oceania. No recoils of any importance were likely before later times.

THE GRAND STRATEGY OF EVOLUTION. By Patten (William)—8°, Boston, 1920, 430 pp. (Richard Badger, The Gorham Press, $5.00)

The author, Professor of Biology in Dartmouth College, fitly characterizes this book as "The social philosophy of a biologist." It is a difficult book to review or even to appraise, it comprises so much. Perhaps the best notion of the work can be obtained by quoting from the author's own summary: "We have seen that the one outstanding fact which now dominates the thought and acts of intelligent men is evolution, or nature-growth, embracing alike all physical, organic, mental and social phenomena in its spontaneous constructive action, and using them all alike in the consummation of its creative purpose. That sovereign outward fact, in all its elemental grandeur, is the immutable axial truth around which man must orient his inward purposes and to it conform his conduct rightly, or suffer self-destructive penalties. It compels man to accept nature's constructive rightness as his ethical standard, and to adopt her constructive methods as his moral code. It compels him to recognize in nature-growth the expression of a creative will; it reveals to him in nature-action the way to augment himself and the instrument to his salvation. His most ardent desire is then to know that will the better to obey it." To which may be added a few phrases from p. 326: "There is no conflict between the basic teachings of science and the instinctive dictates of humanity expressed in broad religious terms. Science seeks truth and discovers rightness. Religion seeks righteousness and discovers truth."

The volume is much more a contribution to philosophy and sociology than to physical anthropology, nevertheless it embraces many statements of biological facts, given in a novel and interesting manner, and it endeavors to apply their lessons to general human concepts and behavior.

DER FOSSILE MENSCH. By Werth (E.)—8°, Berl., 1921, 336 pp., (Pt. 1).

This is the first volume of a work which was evidently intended to give a complete and faithful view of the finds relating to man's antiquity and of the opinions and discussions relating thereto; and so far as the present part goes, has on the whole come nearer to that goal than perhaps any other recent work on the subject, even though American literature remains unknown to the author. The volume is also profusely and well illustrated. It is a very creditable production though from the scientific point of view one feels a lack of original contribution. For German readers the book will be both safe and very useful.

PREHISTORY. By Burkitt (M. C.)—8°, Cambridge, 1921, 438 pp., 47 pl., bibliog.

A handsome volume, devoted mainly to prehistoric archaeology and art, but touching also on many points of interest to physical anthropology. The book is written conservatively and though not without some errors, may be safely recommended to the student. It is not a report of original research, but a compilation based on good personal acquaintance with the field. It ranges itself nicely by the side of Munro's "Paleolithic Man" and Macalister's "Archaeology," and will form a good basis for a future more perfect and perhaps more original edition.

A TEXT-BOOK OF EUROPEAN ARCHAEOLOGY. By Macalister (R. A. S.) —8°, Cambridge, 1921, 610 pp., 184 illustr's., Vol. I—The Palaeolithic Period.

An excellent book and finely printed. Together with Boule's "Fossil Man," Burkitt's "Prehistory" and Osborn's "Men of the Old Stone Age" should be well known by every student of man's antiquity, for these several works supplement and strengthen each other. The book, as the others here mentioned, deals with the whole subject of ancient man, though the larger part is devoted to archaeology. It gives a vast amount of information as well as much interesting discussion, under the heads: Geological Prolegomena; Palaeontological Prolegomena; Anthropological Prolegomena; The Beginnings of Human Life in Europe; The Lower Palaeolithic Stages; The Middle Palaeolithic Stage; The Upper Palaeolithic Stages; The Psychology of Upper Palaeolithic Man; The Mesolithic Period; and The Palaeolithic Period as a Whole.

The second volume of Professor Macalister's deserving work will deal with later man.

The Evolution of Man. Sigma-Xi Lectures delivered at Yale University 1921–22. 8°, New Haven, 1922 (Yale University Press), 202 pp.

"The contents of this book have as their basis a series of lectures bearing the same title which were given at Yale University during the academic year 1921–1922." A similar previous series of lectures was published under the title "The Evolution of the Earth and its Inhabitants."

In the present volume, "the first lecture, by Professor Lull, sets forth the paleontological evidence for the evolution of man. In the second, Professor Ferris gives in detail, largely from anatomical and embryological standpoints, some of the important evidence for evolution which is to be found in the development and structure of present-day man. The third and fourth lectures by Professor Parker and President Angell respectively, constitute a unit in which the evolution of the highly specialized and preëminent nervous system of man together with the development of intelligence, are given consideration. Professor Keller, in the fifth chapter, presents the question of evolution in the various institutions of human society, and finally Professor Conklin sets forth his views with regard to the trend or future of evolution."

As could hardly be otherwise the several parts of the book are not of equal value or thoroughly connected. Also, being based on lectures and designed for a more general perusal, they do not give the detailed substantial results of new research that the professional student of the question would wish for. Nevertheless the book as a whole may well be characterized as one of a good class and well worth reading.

There are however a number of points, particularly in the first section, that call for improvement. On p. 5 we meet once more with the wholly unfounded notion that "Asia is the birthplace of mankind." The matter is made even stronger on p. 38, where we read: "Exploration in Asia now being carried forward under the auspices of the American Museum of Natural History will, it is hoped, yield additional light on the problem of human origins, for all of our evidence [*sic*] points to central Asia as the birthplace of mankind, and to the Miocene, 1,000,000 or 2,000,000 years ago, as the time of his origin." The remains of the Pithecanthropus are spoken of as "human" (pp. 7, 13). There is a strong intimation that the author regards the origin of man as polyphyletic (pp. 9, 35). Under "America" we still read of the Calaveras skull and various other discredited representatives of man's antiquity on this continent (pp. 9, 11). In the remarks about the Rhodesian skull we read of the finding of a second specimen (p. 29) of a similar type, and we also learn of a "part of a lower jaw," specimens with which we are not otherwise acquainted; while on p. 30 it is stated that the Rhodesian skull "itself is not remarkable either for its form or estimated content," while of course its form is the most remarkable thing about it. The ascending branch of the Mauer Jaw is "gibbon-like" and "the age of this venerable relic read in terms of years is at least 400,000, and the associated flints are Eolithic in culture" (pp. 18, 19). The anterior teeth of the Piltdown Jaw are "simian" while the molars are human (p. 22).

The most generally interesting section of the book is that by Conklin on "The Trend of Evolution." It is written in the excellent style of the author and is full of broad and advanced ideas. Also the views presented are an advance over those given by the same author in his "Direction of Human Evolution" (N. Y., 1921), particularly in leaving more of a loophole for possible further evolution. There are nevertheless, in this section some statements with which all students of the question may not agree. On p. 157 we find a very strong statement against the possibility of inheritance of acquired characters—"The effects on development of environment, training and education are not inherited through the germ cells and the hope of permanently improving the human race, or any other species, in this manner can only lead to disappointment and failure." On p. 162—"Not only the history of other organisms but also that of man himself indicates that progress in any particular line is limited. In bodily evolution man has made no very marked progress during the last twenty thousand years at least . . . The physical evolution of man has slowed almost to a standstill . . . Indeed since the times of the Crô-Magnon race, probably twenty thousand years ago, there has been no marked increase in man's cranial capacity, and probably little or no increase in his inherent intellectual ability" since "the only great progress which the human race has made during the past twenty thousand years has been social, and so far as we can now see into the future the progressive evolution of mankind must depend to a great extent upon society." The great distinction between the educated and the uneducated (p. 172 *et seq.*) may not be wholly warranted. The estimate of the mulattos among the negro population of the U. S. on p. 176 is by far too low. Due to increasing intermixtures (p. 176) Professor Conklin believes that "it can only end in the more or less complete fusion of existing races, and it needs only the vision that can look ahead a few thousand years at most to see all races blended into a common stream." On p. 177 we meet anew the obsolete term "red" races. But "Perhaps in future ages the progressive evolution of man will continue somewhere and somehow. If higher species of man evolve in the future it is not unlikely that this will occur, as in the past, in connection with great secular changes, over which man has no control, such as the rising and sinking of continents, the formation of deserts or mountains or oceans, or changes in climate comparable to the glacial and interglacial epochs, during which human evolution made such wonderful progress."

DER MENSCH, SEIN URSPRUNG UND SEINE ENTWICKLUNG. By Leche (W.)—2nd edit., Jena, 1922, 390 pp.

Few alterations have been made in the new edition of this semi-popular natural history of man. Only the chapter on fossil man has been much added to. Parts of the discussion of the results of embryology are perhaps not quite up-to-date. The chapters on the rudimentary organs of the human body and on "man and his nearest living relatives," the primates, are very readable. Good, well-selected illustrations considerably augment the value of this book.

A. H. SCHULTZ.

ORIGIN AND EVOLUTION OF THE HUMAN RACE. By Churchward (Albert)—8°, 1922, 511 pp. (N. Y., Macmillan; Lond., Allen & Unwin).

This is a strange work, a combination of subinformation, militant mysticism and many curious insistent notions. There is nothing about the book to review from a scientific standpoint, for there is no science (though there are some very good illustrations). A few examples of the nature of the statements will probably suffice: (Preface) " . . . the book has been written in various parts at various times, and a busy professional life has prevented the better classification of the subject matter which I should have desired. Nevertheless I contend that the facts brought forward are true and will be found irrefutable;" (p. 3) "the Pigmy was the primary Homo, evolved from a Pithecanthropus Erectus, or Anthropoid Ape, in Africa over a million years ago;" (p. 5) "Original or Primary Man—age 2,000,000 years;" (p. 10) The Egyptian wise men recorded time etc. for over 250,000 years, and have left records of "at least ten Glacial Epochs;" (p. 36) "the c. c. alone proves the Piltdown cranium to be a human skull of the Nilotic Negro class, probably a non-Hero Cult;" (p. 45) "The tall race of Europe were those Hero-Cult Nilotic Negroes who came up from Egypt;" (p. 462) "The oldest human inhabitant of the British Isles was undoubtedly the Pigmy;" etc., etc. There is so much of this, and of statements similar to this on many other matters that one ends the survey of the volume—reading through it is impossible—with nothing but pity.

THE ORIGIN OF MAN. By Headstrom (Birger R.)—12mo., 1921 (Princeton University Press), 100 pp.

"At the end of the Cenozoic . . . dead matter came to life in the form of organisms which by mutual attraction formed small dwarfs, the early ancestors of man."

MAN'S PREHISTORIC PAST. By Wilder (H.)—12mo., N. Y. (Macmillan Co.), 1923, 463 pp., 110 figs.

This small well written volume was doubtless intended as a primer for advanced students, for which it is well adapted. It claims no originality outside of the manner of presentation. It deals with: The Chronology of Prehistory; Material and Methods; European Prehistory of Africa, Asia and the Oceanic Islands; Prehistory of the two Americas; and Known Types of Prehistoric Man. The author is to be credited for a sensible presentation of the subject of ancient man in the two Americas.

EVOLUTION AND CHRISTIAN FAITH. By Lane (H. H.)—8°, Princeton, 1923, XI-214 pp. (Princeton University Press, $2.00).

This book, we are told, is based on a course of lectures given at the request of the students of the University of Kansas and in response to the questions—1) What is the theory of evolution and what are the important facts on which it is based; and 2) What effect has the acceptance of that theory upon one's views of the Biblical account of creation and of the Christian religion?

The volume is a remarkably wholesome production and deserves to be read widely by men and women of education. It deals sensibly and yet in a high class manner with the following subjects: The So-called warfare of science and theology; The fact of evolution; Has man evolved? The geological history of man; The role of the hand in the evolution of man; Some disadvantages of the upright position; The embryology of the mind; The problem of ultimate causation; The origin of the individual vs. the origin of species; What and where is God; Evolution and Genesis; Evolution and Christianity; and The swing of the pendulum. In a brief and yet markedly successful way, the author outlines the indispensable foundations of the scientific deduction of man's evolution; and he then shows in his own words as well as by well selected quotations that the new knowledge can constitute no possible danger to and is by no means incompatible with, true religion.

God or Gorilla. By McCann (Alfred Watterson)—8°, N. Y. (The Devin-Adair Co., $3.00), 1921, 340 pp., 27 illustr's.

A book of misdirected zeal, endeavoring to show "how the monkey theory of evolution exposes its own methods, refutes its own principles denies its own inferences, disproves its own case." Leaning largely on Father Wasmann; overaccentuated sweeping, inaccurate and here and there striving to be forcibly indignant (Osborn)—yet somehow lacking both virulence and impressiveness. It almost seems as though the author were really a better evolutionist than he endeavors to show himself to be—it is hard to see how one who has tasted of the life-blood of so many and such good men could fail to be. Books of this sort do not hurt, only caution.

Les Hommes Fossiles. By Boule (Marcellin). 8°, Paris (Masson & Cie), 1923, 505 pp., 247 figs.

This is the second edition of Professor Boule's already well known book. On the basis of this there has also been prepared an English edition, which when ready will be handled in this country by the Van Nostrand Co. of New York.

The work has a great deal of merit and no student of the subject of early man can well be without it. It is written conservatively and by one who is on the whole the foremost living authority on ancient man in France. It deals with ancient man in general as well as with all the better known finds, and that from the standpoints of archeology, geology and paleontology as well as from that of his physical characters.

The book is divided into ten sections, namely the History of the subject; Chronology; Fossil and Present Apes; the Pithecanthropus; the Problem of Tertiary Man and the Eoliths; the Man of the Lower Pleistocene; the Neanderthal Man; the Man of the Time of the Reindeer; the Transition from Fossil to Actual Man; and Fossil Man Outside Europe. The last chapter is followed by "General Conclusions" and a good index.

Studies in Evolution and Eugenics. By Holmes (S. J.)—8°, N. Y. (Harcourt, Brace & Co.), 1923, 261 pp.

The volume at hand is an above-average scientific, yet non-technical discussion of a line of questions that are of serious contemporary interest. It makes "no claim to unity of treatment. The topics chosen for discussion represent some of the peculiar interests of the writer which have grown out of several years of occupation with the fields of heredity, evolution and eugenics." The matters dealt with are: Present Tendencies in Evolutionary Theory; Beyond Natural Selection; Panmixia and Degeneration; Our Deteriorating Inheritance; Social Betterment and Eugenic Progress; Heredity and the Mind; Is Infant Mortality Selective?; Has Civilization Diminished the Rigor of Natural Selection?; Sexual Selection; Its Present Shortcomings and Future Possibilities; Do Early Marriages Produce Inferior Offspring?; Is Birth Control an Aid or a Menace to Eugenics?; Will Birth Control Reduce Fertility?; Some Misconceptions of Eugenics; Immigration and the Future American; The Biological Effects of Race Mixture; The Biological Fortunes of the Negro.

It is impracticable in the available space to go into a critical discussion of the author's views. Many are excellent though here and there tainted perhaps with a little pessimism; and if not all can be generally agreed to nevertheless they conduce to much thought and reflection.

Pliocene (Tertiary) and Early Pleistocene (Quaternary) Mammalia of East Anglia, Great Britain, in Relation to the Appearance of Man. By Osborn (Henry Fairfield)—*Geol. Mag.*, October, 1922, repr. 8°, 433–441.

The paper which, regrettably, does not deal with critical original research of the author himself, is devoted in the main to showing the rich old fauna of the "Crags" of southeastern England. Notwithstanding the promise in another paper (see below) the only references to man are found in the conclusions; they read: "Man appears in Britain under true Tertiary conditions of the climate, of the fauna, of the flora. Two points are clearly established— First. The discovery of remains of human (Foxhallian) industry within and beneath the Red Crag *adds the highest Primate to this fauna*, namely, a species of man probably referable either to Homo or to Eoanthropus, as made known through the researches of J. Reid Moir and E. Ray Lankester. Second: the next appearance of man is in the Cromerian industry of the base of the Forest Bed, immediately overlying the Weybourn, also made known through the researches of Moir and of Lankester. This is no longer Tertiary man, but Quaternary man, found with a true lower Quaternary fauna and flora closely comparable to that of southern France and of the 40th parallel in the United States."

RECENT DISCOVERIES OF THE ANTIQUITY OF MAN. By Osborn (Henry Fairfield) & Reeds (Chester A.)—*Proc. Nat. Acad. Sc.*, VIII, No. 8, Aug. 1922, 246–247.

A brief paper, intended as an abstract "of two lines of research recently undertaken by the authors which will be published under the titles: *Old & New Standards of Pleistocene Division in relation to the Prehistory of Man in Europe; Pliocene (Tertiary) and Early Pleistocene (Quaternary) Mammalia of East Anglia, Great Britain, in relation to the apearance of Man.*

"At the April, 1921, meeting of the National Academy, Dr. Osborn ventured the prediction that a large-brained type of man would be found in the Pliocene. He was not aware that such a discovery had actually been made in the Upper Pliocene Red Crag deposits near Ipswich, England, by J. Reid Moir; in fact, Mr. Moir's discovery of Red Crag and of sub-Red Crag man was not accepted in England, and it was not until an unmistakable human industrial level was found at Foxhall near Ipswich, in the summer of 1921, that this locality was visited by the French archaeologist Breuil, who announced this important discovery at the Archaeologial Congress at Liège in August, 1921. Dr. Osborn immediately planned to visit this locality and to make a careful survey and review of the animal life which surrounded Foxhall man. This review, fully set forth in the second paper above named, shows that Foxhall man—capable of making ten or twelve different kinds of flint implements, of providing himself with clothing and of building a fire—sets an unmistakable Upper Pliocene date for the antiquity of man, in which he was surrounded by relatively primitive mastodons, rhinoceroses, saber-tooth tigers, and two species of elephants, a fauna closely similar to the Upper Pliocene fauna of the valley of the Arno River near Florence, Italy.

"More recent than the Foxhall industry is that of Cromer on the coast of Norfolk, discovered during the summer of 1921. Cromer is also treated as of Upper Pliocene age by British archaeologists, but it is unmistakably *Lower Pleistocene;* it belongs to First Interglacial time . . . As a result of the researches summarized by the authors, we are now able to fix with considerable certainty the geologic level of the entire succession of human industries, namely, the Foxhallian, Cromerian, Chellean, Achulean, Mousterian, Aurignacian, Solutrean, Magdalenian, and Campignian. We are also able to fix with considerable exactitude the geologic age of the successive races of men, i. e. Trinil, Piltdown, Heidelberg, Neanderthal and Cro-Magnon which appear between Foxhallian and Magdalenian industrial times."

All this only accentuates the great desirability for the various students of these deposits, and of their relation to man, to reach a harmonious conclusion.

THE ICE AGE AND MAN. By Peake (H. J. E.)—*Man*, Jan. 1922, 6–11.

"The divergent opinions held by geologists on the question of the Ice Age and the various views advanced by archaeologists on the relations subsisting between the glaciations and the first phases of human activity, have long hindered a clear understanding of the early days of man. During the last year or two these differences have been tending to disappear, and it is perhaps worth while for one, who has hitherto kept free from all controversies on this subject, to put forward tentatively a scheme which may, perhaps with subsequent modifications meet the views of the varying schools of thought. The scheme is only in outline, and is confined to the evidence in British, Baltic and Alpine regions; for other areas have been equated satisfactorily with one or other of these." Following Penck and Brückner, European geologists generally look on the Ice Age as having presented four separate stages of glaciation, the Günz, Mindel, Riss and Würm, with three interglacial periods, the Günz-Mindel, Mindel-Riss, and Riss-Würm; whilst the post-Würm period is one of gradually diminishing oscillations, merging finally with historic times. In England, on the other hand, "opinion in official geological circles favors the monoglacial theory, based mainly on the view that there is no evidence here for an oscillation in temperature," though a polyglacial theory has also supporters. The author leans to the opinion that "the Mindel and the Günz of Penck are the two maxima of the first glaciation." He then presents his own geological scheme for England and Scotland, correlating it with conditions in Scandinavia and a part of France, and with cultural manifestations. The scheme on the whole appears to be a very reasonable one. The early paleolithic cultures, from the Pre-Chellean to Early Mousterian, are placed in the Riss-Würm interglacial period, the middle Mousterian in the Würm, the late Mousterian to Azilian with the post-Würm oscillations. But there are two serious features in the scheme which are not justified by the author. The one is the placing of those parts of the Ice Age that preceded the Riss, hence fully one-half if not over, of the glacial time, into the Pliocene. The second relatively insignificant and yet seemingly scarcely more justified feature, is the inclusion of the Foxhall flints into the scheme at the bottom of the scale, at a vast distance from even the Pre-Chellean. The advance of the Pliocene to, if not beyond, the middle of the Glacial epoch could only be sustained by the most weighty and convincing facts; while the inclusion of the Foxhall remains when, notwithstanding all that has been written about them, their time-value is till uncertain, serves no good purpose, unless it is to thus graphically show the meaning of the claims for these specimens. The author and his colleagues would earn a very grateful acknowledgment from less favorably situated students by a thorough critical exposé, and if possible a definite settlement, of the whole Foxhall question.

Old and New Standards of Pleistocene Division in Relation to the Prehistory of Man in Europe. By Osborn (Henry Fairfield) and Chester A. Reeds—*Bull. Geol. Soc. Amer.*, 1922, XXXIII, 411–490.

In submitting this work for a review the authors state that "This Synthesis does not claim original observation by the authors in Europe in either of the nine branches of science which it attempts to synthesize. The observations and theories of acknowledged leaders in each of these nine branches are coördinated as accurately as possible from their writings, and in several cases through their own personal revision of our MSS and text . . . This Synthesis seems to us to establish the four-glacial theory on a relatively firm basis; yet it still leaves unexplained the fact that only during the final or Fourth Glaciation was there a real refrigeration of western Europe north of Lat. 43°. The First Glaciation sent its refrigeration only as far south as Lat. 53°."

The undertaking is without question a most praiseworthy one, and due to the nature of the subject, must have proven a difficult piece of work. The authors "have attempted to set forth as accurately as possible the views of the thirty-seven authors chiefly quoted;" with the main object that "this Synthesis may lead to renewed and *synthetic research*, through which alone can these discrepancies be understood." These authors include Antevs, Barrois, Bishop, Boule, Brooks, Bruckner, Chamberlin, Chaput, Commont, Croll, Daly, De Geer, De Lamothe, Depéret, Gagel, Geikie, Gignoux, Harmer, Huntington, Leverett, Mayet, Montelius, Obermaier, Osborn, Penck, Pissot, De Puydt, Sauramo, Schuchert, Soergel, Suess, Taylor, Van Barn, Vayson, H. Virchow, Wahnschaffe, and Wright. The "synopsis and partial synthesis" is supplemented by a "Review and Critique of the Penck-Brückner, De Geer, Depéret Systems," by Leverett, Alden, de Martonne, Johnson and Davis, and the volume is illustrated by numerous charts and figures, and supplemented by five pages of bibliography.

There is little to be added to the above, except a few words as to the part by Osborn and Reeds themselves (470–472). Facing p. 470 we find a chart by these two authors giving their present views on "Correlation of Marine, Terrace, Climatic, Racial, Culture and Life Stages." This chart is not easy to digest and there seems justified a call for simplification, but otherwise it leaves little to be desired. It marks a decided advance over a similar chart by the same authors published in Osborn's well-known "Men of the Old Stone Age." So far as human remains are concerned, the only somewhat serious objection that may be made is to the unqualified placing of the Foxhall remains into the Pliocene, at an immense distance from the "Early Chellean." Opinion concerning the exact nature and age of these remains has not as yet become definitely crystallized, even in England. But this is rather a minor point in comparison with the value of the whole work and the bringing together of hardly accessible data published in various languages, for which all students of the subjects involved will be grateful.

THE ICE-AGE AND MAN: A NOTE ON MAN. By Brooks (C. E. P.)—*Man*, May, 1922, 75–76.

The author, as a geologist, partly supports, partly tends to correct Peake's classification of the Quaternary English deposits. The Chalky Boulder Clay, which Peake regards as Würmian, he considers to be Mindelian or belonging to the Mindel-Riss interglacial period. He agrees with Peake in throwing doubt "on the validity of the Gunz-Mindel interglacial. I should like to go further and divide the whole Ice Age into two glaciations only, the Gunz-Mindel and the Riss-Würm, both composed of several oscillations and re-advances. Recent work by Scandinavian geologists suggests that over the greater part of Norway and Sweden the ice only completely melted away once during the whole glacial period, but then for a very long interval. After the Rissian readvance there is no return of a really temperate fauna until the close of the Ice Age."

To the above J. E. Marr adds two paragraphs with the first of which (the second concerning more a local problem) many students of the question will fully agree. They are: "The views of the relationship of the different stages of palaeolithic times are so varied and conflicting that nothing short of a full discussion of the problem is of much use. Even at present, some hold that palaeolithic man dwelt in this country in pre-glacial times, others that he is entirely post-glacial, others, again, that some of the palaeolithic stages belong to an inter-glacial period. There is a tendency for the upholders of the different views to pay scant attention to the arguments of their opponents. The ideas of those who adopt the third position above mentioned seem to be gaining ground, but the writer feels that much more information must be obtained before the question can be considered as being finally settled."

THE ICE AGE AND MAN IN HAMPSHIRE. By Palmer (L. S.)—*Man*, July 1922, 106–110.

In a well written account, Dr. Palmer outlines the geological and archeological conditions of the Hampshire basin, and gives a sensible tentative graphic outline of the "geology-culture correlations" in this region. He shows the connection of the Acheulean and Chellean cultures with the Riss (and possibly Mindel-Riss), the Mousterian with the Würm and post-Würm, the Aurignacian with the Bühl and the Magdalenian with the post-Bühl climatic period or subdivision of the Ice Age (the Bühl and post-Bühl periods being smaller oscillations manifested in the last or post-Würm ice recession). As to the "Mousterian and post-Mousterian cultures, the foregoing conclusions are in close agreement with those of Peake and also with a chronological table recently published by Burkitt, and thus they agree with the equation by which Mousterian man is coupled with the Würm ice epoch."

NOTES ON THE CHRONOLOGY OF THE ICE AGE. By Burkitt (Miles C.) —*Man*, Dec. 1922, No. 104, pp. 179–182.

This is, regrettably, but a glance on the subject, but a glance that for its soberness and precision calls for a grateful acknowledgment by the students of the question. If one thing above all is needed in this important and difficult field, it is a thoroughly sane as well as modernly scientific treatment, which will brush off the accumulated cobwebs and bring us into close touch with plain realities. The author, who has only recently given us his valuable "Prehistory" (8°, Cambridge, 1921), and who is evidently more directly acquainted with the bulk of the field of Early Man in Europe than any other recent writer, brings forth evidence that, (a) "A part, at any rate, of the Lower Palaeolithic is post-Riss[1] . . . The relative chronology of the archaeological divisions in France shows us a Chellean with a warm fauna underlying an Achulean with a cooler fauna. It is logical, therefore, to add to the above conclusion that in the warmest times between the Riss and the Würm the Chellean culture was flourishing and was followed, as the cold of the Würmian glaciation began to be felt, by the Acheulean, which appears to be only a development of the Chellean . . . (b) A Würmian date must be assigned to the Mousterian. Whether the cultures flourished just before, during or just after, remains a problem. The writer believes that the Mousterian straddled across Würmian times and that in some localities it will be found just before, in some during, and in others just after . . . (c) The Magdelanian culture is post-Würmian, and, from the above considerations, must be assigned to the Bühl epoch. (d) In England, most of the "Upper Palaeolithic industries appear, as far as has yet been discovered, to be Aurignacian in various stages of development." With the researches of Reid Moir on "Tertiary Man" the author is "not here concerned."

The appearance in short succession of the serious contributions to this subject by Brooks, Burkitt, Marr, Palmer and Peake is a welcome sign of a renewal of true scientific interest in questions which will possibly prove easier of solution in England than on the continent, and which will have no small effect on the much needed clearing of the still present mists in France, Belgium and other parts of western and central Europe.

MAN AND THE ICE AGE. *Nature*, Nov. 4, 1922, 617–618.

A good reference article giving in a concise form a report on the important discussion which took place at the Hull meeting of the British Association by the sections on Anthropology, Geology and Geography, on the subject of the relation of man to the various subdivisions of the Ice Age in Britain. No definite agreement was reached, nevertheless the discussion was most useful and it has stimulated the production of a number of good papers which have since been published in *Man*. (See accompanying reviews).

OUR ANCESTORS ARRIVE IN SCANDINAVIA. By Osborn (Henry Fairfield)—*Natural History*, March-April, 1922, 117–134.

A popular, attractive and nicely illustrated article, "the fourth in the series on early man in Europe," dealing on the basis of the researches of De Geer and Montelius with man's occupation of Scandinavia and the cultures he passed through in that territory. Curiously, no mention is made of the Lapps or old Finns, who probably played a not unimportant part in the original settlement of the peninsula. The chronological table of cultures for Scandinavia is now probably more definite and more nearly correct than that of any other European country. According to this, man reached the southern coasts of the country during the latter part of the Old Stone Age, or about 11,600 B. C. Montelius believed these reindeer hunters were the [much abused] Crô-Magnons, which opinion Professor Osborn seems to accept (p. 121) but rejects later: "There is no evidence of the occurrence of the broad-cheeked Crô-Magnon type of late Palaeolithic Age in the oldest Scandinavian graves." (p. 127).

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[1] In the generally adopted nomenclature of the various phases of the Glacial Period, the term "Riss" designates the one before the last and the term "Würm" the last ice invasion.

Der Java-Trinil-Fund "Pithecanthropus." By Ramström (M.) —*Upsala Läkareför. Förhandl.*, 1921, XXVI, art. 29, 37 pp.

Neither the Pithecanthropus nor the Eoanthropus remains, in the author's opinion, are capable of giving any definite conclusions as to man's genesis. The Pithecanthropus remains are of Quaternary, not Tertiary age. The same deposits gave also remains of an ape (the teeth), and of a man (the femur). The skull-cap has shown itself in all essentials as that of a chimpanzee, and notwithstanding its size cannot be regarded as a transitional form between apes and man. The femur is wholly human and resembles that of *H. aurignacensis;* it does not belong to the skull. The results of the author's study point to the conclusion that the Aurignacian man originated in the Far East. All of which is rather radical and not demonstrated to the satisfaction of other students of the question.

The Problem of the Rhodesian Fossil Man. By Smith Woodward (A.)—*Science Progress*, April, 1922, 574–579.

"The Rhodesian cave man represents a distinct species, *Homö rhodesiensis*, which differs from *H. neanderthalensis* in his erect skeleton as well as his relatively large face. This additional feature again suggests that among extinct races the South African is later than the European, just compared.

"The lands of the Southern Hemisphere have indeed always been the refuges in which old types have survived long after they became out of date and displaced in the more progressive Northern Hemisphere. They are still the refuges of many antique forms of life which we otherwise know only by fossils. The discovery in the Rhodesian cave now seems to show that races of unfinished men were among the latest refuges in the south. The new race in question does not fill precisely any gap in a direct series uniting modern man with his ape-like ancestry. It merely represents one of the latest variants among the multitude which will eventually be discovered to have passed away as failures during the progress of man in the making. It is an advanced stage in which arrested brain-development accompanies enlargement instead of refinement of the face."

Předmost eine Mammutjager-Station in Mahren. By Absolon (Karel)-Repr.from Klaatsch-Heilborn's"DerWerdegang der Mensch heit und die Entstehung der Kultur," 8°, Berlin, 1918.

A general account of the very valuable Předmost finds (Aurignacian), with excellent illustrations of two of the skulls, showing the still marked supraorbital arches and other transitional features. (A report on the Předmost skeletal remains by Professor J. Matiegka is nearing publication.)

DER DILUVIALE MENSCHENFUND VON OBERCASSEL BEI BONN. By Verworn (M.), R. Bonnet & G. Steinmann. 4°, Wiesbaden, 1919, 193 pp., 28 pl.

In February 1914, the University of Bonn was notified by an intelligent quarryman of the discovery of two skeletons and some cultural objects deep in basaltic rubble near the small town of Obercassel. Upon examination the find proved to be that of two ancient burials, an adult male and female. The bodies had been buried in earth and in the course of time the burials became covered by broken pieces of basalt and other accumulations. The earth about the bodies was impregnated with red ochre that had been buried with the bodies, and accompanying the bodies were a number of interesting objects of bone. Animal bones found on the spot and in the vicinity comprised the reindeer, cave-bear, antelope and other forms of later diluvial fauna. The age of the remains was determined to be early Magdalenian.

The remains, which are preserved in the Anatomical Institute of the Bonn University, where, thanks to the courtesy of Prof. Sobotta, they were seen by the reviewer in 1922, are remarkably well preserved, and constitute one of the most valuable finds from near the end of the glacial epoch. They are closely related to the even more valuable and slightly earlier remains of Předmost, a report on which is now nearing publication. Both the skulls and the bones, while in general approaching modern form, still show various primitive features, some of which, such as the still plain supraorbital arch in the male, appear plainly transitional from the older Neanderthal type. Both skulls are dolichocephalic (M. 74.8, F. 71.3) and large (Cran. capac., M. *ca* 1500, F. *ca* 1370 cc.) The lower jaws and teeth are fairly modern; the lower jaw of the male, however, as well as his zygomatic arches, indicate great muscles of mastication. The stature in the male was approximately 172.5, in the female 147 cm. The individual bones present many features of interest.

The find and remains are thoroughly described and beautifully illustrated by the three well-known authors.

Casts of the skulls and of parts of the skeletons have been furnished, thanks to Professors Sobotta and Steinmann, to the U. S. National Museum.

NEOLITHIC CAVE DEPOSIT AT SHA-KUO-T'UN.—*Proc. Anat. & Anthrop. Soc. of China*, Peking, 1920–21.

"A rich deposit of human skeletal material and a large number of associated Neolithic artifacts have recently been discovered by Dr. J. G. Andersson, Mining Advisor to the Chinese Government, in a limestone cave at Sha-Kuo-T'un. In the subsequent work of excavation, Dr. Andersson was assisted by Dr. Davidson Black of the Peking Union Medical College. The character of the deposit indicates that the site was not an ancient burial place. The skeletal material was largely human, there being but relatively few remains of lower mammals except in the upper stratum of the deposit. No complete skeletons nor intact skulls were found. The richest finds of human material and artifacts were made in a deeply-situated and quite sharply defined blackened stratum, in which dissociated skeletal parts, for the most part fragmentary and in many cases charred, were scattered in the utmost confusion. The remains of more than a score of individuals of all ages and both sexes were recovered in this stratum which was overlaid by undisturbed cave loam to a depth of from 0.5 to 0.8 metres. A report on the topography of the cave and its locality, with a description of the artifacts, will be made by Dr. J. G. Andersson, and together with a report on the human skeletal remains by Dr. Davidson Black, will appear subsequently in the "Palaeontologica Sinica."

ARCHAEOLOGICAL RESEARCH IN INNER MONGOLIA. By Andersson (J. G.)—*Proc. Anat. & Anthrop. Soc. of China*, Peking, 1920–21, 2 pp.

At the annual meeting of the Anatomical and Anthropological Association of China, Dr. Andersson gave an account of his archaeological observations on Inner Mongolia which are also of interest to Physical Anthropology. He has been able to establish the following archeological sub-divisions: The Epoch of Agricultural Colonization, probably Ming Dynasty; the Epoch of Stone Effigies; the Neolithic Epoch. Palaeolithic remains are still wanting. It is to be hoped that the paper may soon appear *in extenso*.

THE DESCRIPTION OF A NEANDERTHALOID AUSTRALIAN SKULL, WITH REMARKS ON THE PRODUCTION OF THE FACIAL CHARACTERISTICS OF AUSTRALIAN SKULLS IN GENERAL. By Burkitt (A. St. N.) & J. I. Hunter—*J. Anat.*, 1922, LVII, pt. 1, 31–54.

A description with measurements and illustrations of an Australian male skull with a remarkably primitive Neanderthaloid vault. The outstanding features of the specimen are, a low capacity (1211 c. c.); general massiveness and great thickness of the vault; receding forehead; great absolute length of the cranium; massive undivided tori supraorbitales and marked projection of the glabella in the region of which unusually large frontal air-sinuses separate the two tables of bone; pithecoid conformation of the occipital region and the presence of a well defined torus occipitalis. The face is less primitive than the cranial vault exhibiting orthognathism and a leptorrhine nasal region.

American Journal of Physical Anthropology

VOLUME VII APRIL–JUNE, 1924 NUMBER 2

GROWTH STUDIES ON PRIMATES BEARING UPON MAN'S EVOLUTION

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As the title implies, the author has used ontogenetic conditions in an attempt to elucidate certain questions of human evolution. With such speculations one enters the precarious and much contested domain of the biogenetic law, or, more properly, the recapitulation theory. Since Haeckel formulated this theory his well-known version has been subjected to alterations, until to-day we speak of ontogeny repeating the developmental conditions of ancestral forms rather than their adult stages. Morgan (1919) is of the opinion that such repetition can even be interpreted as "embryonic survival" instead of phyletic contraction. In any case, analogous ontogenetic processes in different animals are and must be regarded as conclusive proof of a common ancestry. For instance, the transitory appearance of gill-slits in the early development of man and their occurrence in young fishes undoubtedly point toward one and the same original stem for the two. In this case we can go farther and conclude that this ancestor must have had gill-slits not only in a developmental stage but at completion of growth as well, since their first appearance in evolution merely as a short-lived ontogenetic structure is unthinkable.

Instances such as this, in which embryonic conditions permit conclusions in regard to the phylogeny of the adult body are not as numerous as findings which merely prove some evolutionary relationship and otherwise contribute nothing to a hypothetical reconstruction of ancestors. In the latter category may be mentioned the proportionately large brain part of the head of primate fetuses, which does not indicate, as Ranke and Kollmann had claimed, a large and well-rounded head in our adult ancestors, but shows only the close relationship between man and other primates. A reduction in relative head size with advance in growth occurs in monkeys and apes as well as in man, and is fully as marked. This difference between relative head size in early and in late growth is explained by a general rule of development, according to which the cephalic end of the body shows an initial acceleration as compared with the more caudal portions.

TABLE 1. The lengths of the different regions of the praesacral spine in percentage of the total length of the praesacral spine. The percentages for adult primates after Keith (1903).

Age	Adult			Infant			Fetus		
Region	Cerv.	Thor.	Lumb.	Cerv.	Thor.	Lumb.	Cerv.	Thor.	Lumb.
Semnopithecus	16	41	43	—	—	—	—	—	—
Macaque	16	42	42	—	—	—	—	—	—
Man	22	46	32	25	48	27	26	49	25
Gibbon	20	48	32	—	—	—	—	—	—
Gorilla	23	48	29	—	—	—	—	—	—
Chimpanzee	23	50	27	—	—	—	—	—	—
Orang-utan	26	50	24	23	54	23	23	55	22

In the author's last paper (1923) reference was made to this rule in connection with the growth conditions of the extremities. That growth of the trunk, likewise, takes place under the influence of this rule can be shown by the age changes in the spinal column. Table 1 gives the proportions of the different regions of the praesacral spine for adults of various primates and also the age changes in these proportions in man and orang. A study of this table reveals the fact that these relative lengths are practically the same in the human fetus as in the adult ape, especially orang. However, this is of no phylogenetic significance; in other words, ontogeny does not repeat, or even resemble, phylogeny on this point. For instance, the lumbar portion of the spine in primates shows in evolution a tendency toward reduction, both in relative length (from 42 in Semnopithecus to 24 in orang), and in the number of segments (from 7 in lower monkeys to sometimes only 3 in orang), man being less advanced in this respect than anthropoid apes. Ontogenetically, the lumbar region behaves in just the opposite way from what it shows phylogenetically; i. e., it increases in relative length, at least in man, orang, Colobus (Schultz, 1924), and Alouatta (Schultz, 1921). This increase is again explained by the embryological rule of an initially retarded development of the caudal region of the body. This in turn necessitates subsequently a more intense rate of growth in that region, for instance, in the lumbar as compared with the thoracic and cervical spine. The correspondence in these ontogenetic changes in spine proportions constitutes further proof of a common origin for the different primates.

It is a well-known fact that an external tail occurs regularly in the human embryo. This tail possesses more than the number of segments and spinal ganglia that persist.[1] The most distal portion of the free tail becomes transformed into a caudal filament (Fig. 1, A), which slightly later is resorbed or cast off. The large majority of recorded cases of external tails in children (Harrison, 1901, Wiedersheim, 1908) are to be regarded merely as persistent caudal filaments; no vertebral anlagen ever reach into the appendage and practically all persistent free tails in children contain neither cartilaginous nor bony elements (so-called soft tails). The view that the caudal filament in the human embryo is an indication of a formerly longer tail has had many adherents. However, an identical filament is found very frequently on the distal ends of the long tails of monkey fetuses (Fig. 1, B), the only difference being that here they develop slightly later and normally persist longer. Further, particularly comparative, studies are necessary before the rôle of this filament is fully understood.

While in monkeys the tail grows faster than the trunk, in fetal as well as in postnatal life,[2] in man it reaches its maximum relative length in the course of the second month of intrauterine life, whereafter the external tail becomes overgrown by the neighboring parts and disappears from the surface. As shown by Fig. 2, the tip of the coccyx in a fetus of ten weeks is still slightly below the level of the buttocks, but in the course of growth it moves slowly and steadily in a cranial direction. Even after birth this migration of the caudal elements of the spine persists to a slight degree, completing the ontogenetic process of a reduction of the tail, a process which consists in a decrease in the number of segments and in relative length, as well as in the shifting of the tail in a proximal direction. Furthermore, it is generally assumed that such structures of the body as are being reduced to a rudimentary state are marked by an unusually high variability, and it can be scarcely denied that in shape and number the coccygeal vertebrae are more variable than any of the other vertebrae.

The shape of the chest undergoes considerable change in the course of growth in all primates. Table 2 gives an outline of these age differences in a fairly representative series of the different groups.[3] In man, orang-utan, and gibbon the chest index increases with advance in growth, and in all three the chest width considerably surpasses its depth in the adult stage. In man the chest index is below 100 up to the eighth week of fetal life; in gibbon this proportion persists slightly longer. In contrast to man and apes, the index decreases with advance in growth in all monkeys and in Lemur. Because of these diametrically opposed age changes in the lower and the higher primates the shape of the chest in the different primates is more alike in an embryonic and early fetal stage than in adult life, another fact that lends weight to the theory of a common ancestry for all primates, including man.

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[1] Vertebral anlagen for the coccyx in the embryo frequently number as many as 7, sometimes 8, while in adult man there are never more than 6, usually only 4 or 5. In adult orang-utan the reduction of the coccyx has gone still further, since normally it consists of only 3 vertebrae and in rare instances of only 2 (according to X-ray pictures).

[2] This is demonstrated for Pithecus and Semnopithecus by Schwalbe (1911) and for Colobus and Alouatta by the author (1921, 1924).

TABLE 2. Chest index (transverse diameter in percentage of sagittal dimaeter). In this and the following tables the indices for man are approximate means, for other primates they are from one specimen only or, where two numbers are given, they represent the range of variation of two or more specimens. The development (but not the actual age) of the different monkey fetuses in a given perpendicular column corresponds approximately to that of the human fetuses in the same column.

	Age						
	Prenatal (month)				Postnatal		
Primate	3rd	4th–5th	6th–8th	9th–10th	Infantile	Juvenile	Adult
Homo	110.0	117.0	117.0	118.5	——	——	130.5
Pongo	——	111.5	110.0–112.0	——	115.2–123.4	132.2	——
Hylobates	98.4	113.3–117.3	106.0–114.2	123.0	117.8	115.5	129.4
Colobus	——	104.3	96.8–106.6	103.2	——	89.8	90.4
Lasiopyga	——	——	——	100.0	——	——	89.0
Pithecus	——	——	93.0–96.0	90.7	89.2	90.0–92.1	90.3
Papio	——	95.9	94.6–97.5	87.6	86.9–89.4	80.8–84.9	84.4
Cebus	——	96.4	95.9	——	——	92.9	88.2
Alouatta	100.0	106.3	102.5–102.9	97.0	95.4	92.1–96.4	78.1
Lemur	——	——	——	110.2	——	96.6	91.7

In the opinion of Wiedersheim and others, the narrow and deep chest of the human embryo repeats a quadruped phylogenetic form of ancestry, since in quadrupeds, due to the weight of the thoracic organs, the chest is greater in a sagittal than in a transverse direction. It is not to be doubted that our ancestors once were quadrupeds nor that gravity exerts a very noticeable influence upon the chest proportions after birth,[4] but the above quoted application of the recapitulation theory must nevertheless be considered unjustifiable. The chest shape in early embryonic life is conditioned by the position and growth of heart and liver. Furthermore, since in lower monkeys the chest is relatively much broader in the fetus than in the adult, to be consistent one would have to argue that the ancestors of the monkey had an upright posture, which, of course, could not be maintained.

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[3] Somewhat more extensive tables and the exact species names, sizes, etc., of this material will be given in the detailed growth studies of the author, to be published in the near future in Contributions to Embryology, Carnegie Institution of Washington.

[4] This is shown, for instance, by the flat broad thorax of the sloths which live permanently in a suspended position.

Mollison has pointed out that among all the primates man has the lowest placed nipples. Table 3 shows that this distinction does not come about until rather late in growth, since in fetal life the nipples are at times situated even relatively higher in man than in some other primates. In man alone are the values for this index lower in postnatal than in prenatal development, while in all apes and monkeys this relation is reversed. The chiefly terrestrial baboons come closest to man in regard to the relative position of the nipples. From this it would seem justifiable to argue in a general way that both the extremely low position of the nipples in man and their exceedingly high position (close to the axillae) in such primates as orang-utan and Alouatta are comparatively recent specializations and that the common ancestors of man and other primates most likely had nipples situated somewhere between these extremes.

TABLE 3. Relative position of nipples (distance: symphysion to level of nipples in percentage of anterior trunk height). The number for the juvenile chimpanzee is after Schlaginhaufen (1907) and for the adult chimpanzee and orang-utan after Mollison (1910).

	Age						
	Prenatal (month)				Postnatal		
Primate	3rd	4th–5th	6th–8th	9th–10th	Infant	Juvenile	Adult
Homo.....	78.0	76.0	79.0	80.0	——	——	73.0
Pan.......	——	——	——	83.4	——	87.9	86.7
Pongo.....	——	84.9	85.0–85.8	——	84.7–90.4	97.1	89.3
Hylobates..	——	83.3–83.8	80.5–83.3	79.1	87.2	89.0	85.7
Colobus...	——	85.6	85.0–85.9	87.1	——	90.8	90.3
Lasiopyga..	——	——	——	78.3	——	——	81.1
Pithecus...	——	——	78.3–78.9	79.6	82.8	80.4–83.0	82.0
Papio.....	——	76.4	73.4–76.0	80.5	77.4–78.5	76.9–79.5	79.7
Cebus.....	——	79.7	80.2	——	——	81.8	82.9
Alouatta...	83.0	84.0	85.3–87.7	85.6	89.4	89.9–97.5	97.7
Lemur.....	——	——	——	71.5	——	83.9	86.2

The total length of the upper extremity in relation to the trunk height is considerably shorter in man than in any of the anthropoids, but is markedly longer in man than in any of the monkeys, with the exception of the highly specialized Spider monkeys. While, therefore, man occupies a conservative position in regard to his relative arm length, he far surpasses any other primate in relative length of his lower extremity. During individual development these different specializations in man and anthropoid apes make their appearance at quite different periods. As shown by Fig. 3, at birth the extreme arm length in apes is already well defined,[5] but the unequaled length of the lower limb of adult man is at this time not yet even indicated, since the two apes slightly surpass the human newborn in lower limb length. In view of the fact that the typical and marked lengthening in the upper extremity of apes develops so much sooner than the unique but late increase in lower limb length of man, it seems perhaps fair to assume that this human specialization is phylogenetically a later acquisition than the former characteristic of apes. This, naturally can only be a speculation, not a conclusive argument; further advance in our knowledge of growth may bring forth a different and more direct explanation or reasons for contradicting and replacing the application of the recapitulation theory. This has happened in connection with a statement made by the author in his last paper (1923): "The fact that the upper limb reaches a maximum relative length in the middle of fetal development may be regarded as lending support to the theory that at some time in the evolution of man his arms were longer than they are in recent human races." Additional material and study have shown in the meantime that quite analogous ontogenetic changes in relative upper limb length occur in practically all primates and this not only in forms with proportionately short upper limbs but also in the long-armed gibbon and orang.[6] This new observation renders the ontogenetic changes in human arm length valueless as evidence for the above mentioned phylogenetic theory, but it establishes a further instance of close harmony in the development of man and other primates which helps to strengthen the conviction of a common origin for all.

The last mentioned conclusion is reached also in regard to age changes in the proportion between forearm and upper arm length. These changes, as shown by Table 4, occur in a strictly analogous way in all primates, since the index is found to increase with advance in growth not only in man but likewise in apes, monkeys, and lemurs. Among these, man (particularly the white race) and most likely gorilla have the relatively shortest forearms. A forearm length considerably exceeding that of the upper arm, such as found in adult gibbon (110.3), Erythrocebus (105.4), Papio (104.7), and Lasiopyga (102.7), is not attained until rather late in life and hence may perhaps be regarded as a comparatively recent extreme specialization.

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[5] It should also be noted in this connection that the difference in relative upper limb length between newborn orang and chimpanzee is as great as between the latter and the human newborn. At the end of the fifth month the relative upper limb length of human fetuses reaches a maximum of 150 but even then this is far exceeded by an orang fetus of corresponding development, the index of which amounts to 196.

[6] The relative length of the upper extremity shows an initial increase in all primates, reaching its maximum at varying stages of growth, and followed by a subsequent decrease whch, however, in some forms, such as man, may change still later into a second rise. That the maximum in this relative measurement is attained before, and is also greater than in, adult life is shown by the following examples: Relative length of upper limb in orang: juvenile 280.5, adults (Molllison) 223.6; gibbon: infant 280.0, adult 230.8; Colobus: fetus 140.0, adult 114.6; Pithecus: fetus 167.6, adult 126.7; Papio: newborn 170.1, adult 140.0; Cebus: fetus 156.3, adult 121.6; Alouatta: fetus 189.2, adult 151.2.

TABLE 4. Brachial index (length of forearm in percentage of length of upper arm). The index for the juvenile chimpanzee is after Schlaginhaufen and for the adult chimpanzee and adult orang-utan after Mollison.

	Age						
	Prenatal (month)				Postnatal		
Primate	3rd	4th–5th	6th–8th	9th–10th	Infantile	Juvenile	Adult
Homo.....	73.0	76.5	78.0	79.0	——	——	83.6
Pan.......	——	——	——	88.8	——	89.7	93.7
Pongo.....	——	88.4	88.1–91.0	——	91.9–97.3	97.6	96.3
Hylobates..	——	90.5–91.5	90.0–95.2	97.2	106.6	105.3	110.3
Colobus...	——	87.0	90.0–94.4	91.8	——	97.3	101.6
Lasiopyga..	——	——	——	97.9	——	——	102.7
Pithecus...	——	——	92.7–93.9	93.7	95.1	95.0–96.7	97.5
Papio.....	——	90.9	93.5–100.3	99.7	101.3–101.8	104.3–105.8	104.7
Cebus.....	——	88.0	86.7	——	——	90.2	94.2
Alouatta...	79.4	84.4	86.1–86.8	84.8	90.8	92.4–95.0	94.0
Lemur.....	——	——	——	94.9	——	95.8	96.1

In connection with the development of the primate forearm, there exists another point of interest which is of evolutionary significance. On the ulnar side of the forearm, close to the wrist, sinus hairs occur in many mammals; they are implanted in a more or less distinct round elevation or hillock of the skin, receive a branch of the ulnar nerve, and are interpreted as touch organs. Beddard (1902), who studied their distribution among mammals, concludes that "the most salient feature as to the absence or presence of the carpal tuft is its nearly universal existence in the Lemurs and the absolutely universal absence in the monkeys." He goes on to state: "It is not without interest to be able to bring forward a character which seems to absolutely distinguish these two divisions of the Primates." The validity of this statement was soon disproved, since Fréderic (1908) found a carpal hillock containing one sinus hair in adult Hapale jacchus. During the examination of four Colobus fetuses, belonging to three different species,[7] the author discovered in every one an analogous carpal hillock containing one to four sinus hairs (Fig. 4). However, in no adult Colobus observed was there any trace of these left. This merely transitory appearance of carpal sinus hairs in Colobus is very similar to the condition in Tarsius spectrum, where Keibel (1907) found the hillock to make its first appearance in an embryo of 15 mm. CR.; later one vibrissa occurs on this hillock, appearing, like all vibrissae, before any lanugo is present. Finally, in adult Tarsius these structures become completely lost.

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[7] Fetuses of two of these species are described by the author in a special paper (1924); a fetus of a third species (Colobus caudatus kekuyuensis, 143 mm. CR.), which was obtained after sending the manuscript to press, shows only a very small hillock with one short black hair on it.

The discovery of a carpal hillock in man, first reported by Henneberg (1915) and later by Broman (1920), heightens the interest in this feature. The author has gone over a considerable series of human embryos and fetuses and has found the hillock well defined in five specimens ranging from 10 to 23 mm. CR. (Fig. 5). Broman figures it in a fetus of 28.5 mm. CR. In all likelihood, this hillock in man is not present at a much earlier nor a much later stage of development; it never persists to a time when sinus hairs could grow out of it, and is quite rare.

In summarizing these notes, it may be stated that carpal vibrissae do occur in monkeys, contrary to the belief of Beddard. In the platyrrhines they are present in one of the lowest forms, Hapale, where they exist throughout life, numbering, however, only one. Among catarrhines the Colobus monkeys possess these vibrissae, although in only a passing period of growth. In man the carpal hillock alone is found early in ontogeny and in only a small percentage of cases, and persists but a short time. The distribution of the carpal hairs among primates, together with the infrequency, rapid development, and subsequent resorption of the preparatory hillock in man, proves clearly the atavistic nature of this structure in the latter.

There is a striking similarity in all primates in the development of the hand and, like the previously mentioned instances of correspondence in ontogenetic processes, this also is claimed, on the basis of the recapitulation theory, as proof of the close relationship between monkeys, apes, and man. According to Table 5, and as shown also by figures 6 to 8,

TABLE 5. Hand index (hand breadth in percentage of toal hand length).

	Age						
	Prenatal (month)				Postnatal		
Primate	3rd	4th–5th	6–8th	9th–10th	Infantile	Juvenile	Adult
Homo....	57.8	53.0	53.0	52.7	——	——	45.0
Pongo....	——	34.0	37.4–37.0	——	36.8–31.5	29.2	——
Hylobates	——	33.1–29.6	31.0–29.2	29.0	23.5	24.1	24.6
Colobus ..	——	41.4	38.7–38.0	35.3	——	31.5	29.1
Lasiopyga	——	——	——	34.5	——	——	33.3
Pithecus..	——	——	39.3–38.7	36.5	35.7	35.9–35.0	33.3
Papio....	——	47.0	45.0–42.4	43.8	39.5–36.0	38.5–41.5	42.0
Cebus....	——	42.1	43.5	——	——	38.5	36.0–34.0
Alouatta .	42.9	40.0	40.5–39.5	39.1	36.5	36.2–32.7	33.9–31.7
Lemur ...	——	——	——	49.1	——	32.9	30.6

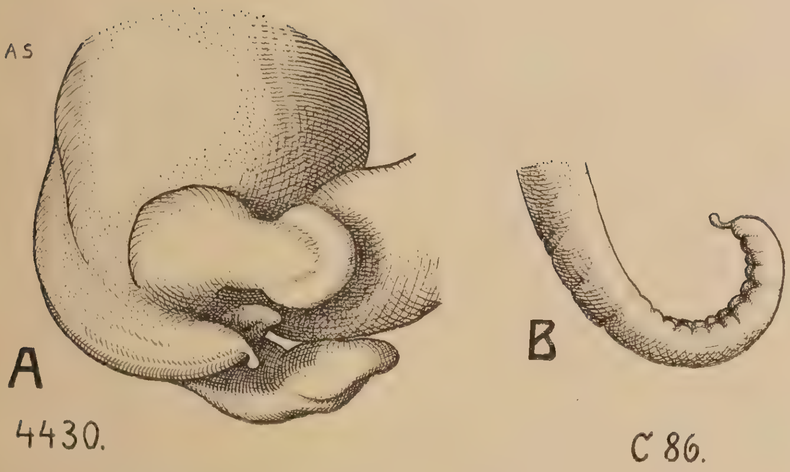

Figure 1. (A) Caudal region of human embryo (14 mm. CR.) showing external tail with caudal filament. (B) Distal end of tail of a fetus (107 mm. CR.) of Cebus capucinus showing the caudal filament.

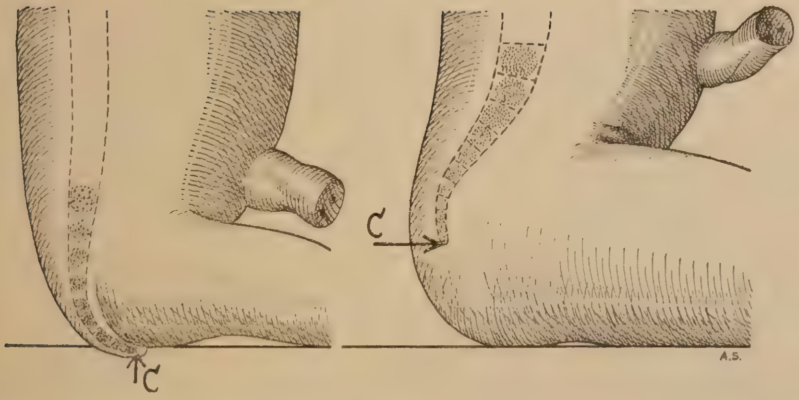

Figure 2. Diagrammatic representation of the migration of the tip of the coccyx (C) in relation to the level of the buttocks. Human fetus of 10 weeks on the left, human newborn on the right.

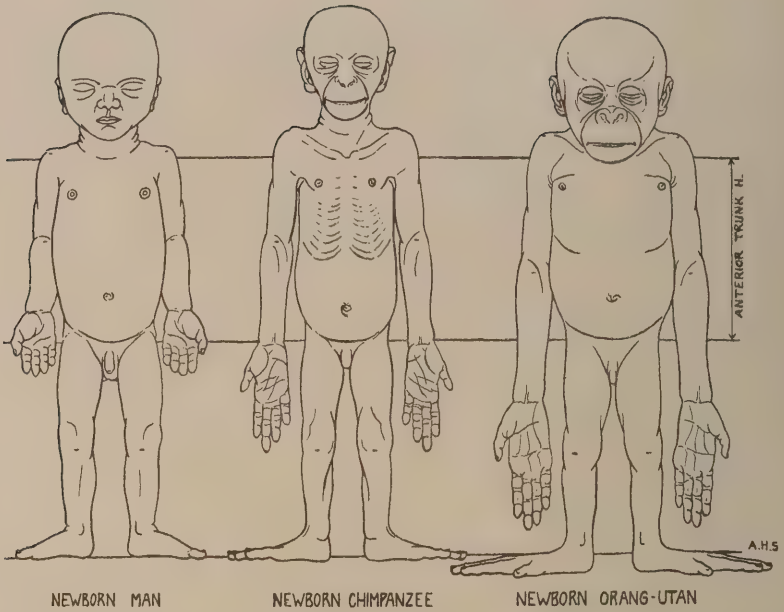

Figure 3. Diagrammatic representation of the exact body proportions of newborn man, chimpanzee and orang-utan, all reduced to the same anterior trunk height. Note the relative length of the extremities.

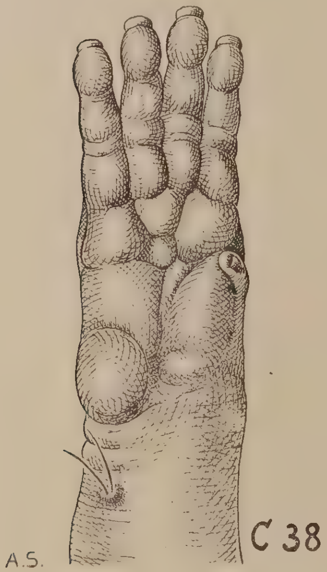

Figure 4. Hand of a fetus (112 mm. CR.) of Colobus abyssinicus ituricus, showing the carpal hillock with two sinus hairs and the rudimentary thumb.

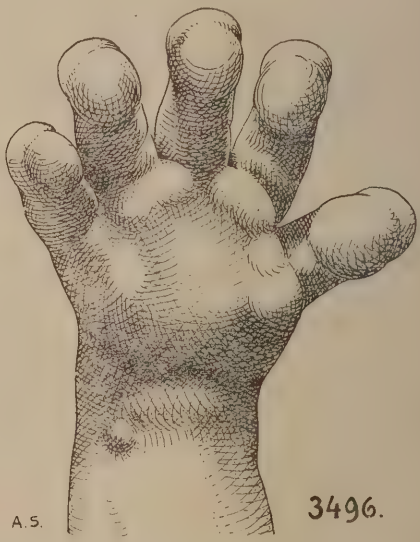

Figure 5. Hand of a human fetus (23 mm. CR.) showing the rare carpal hillock.

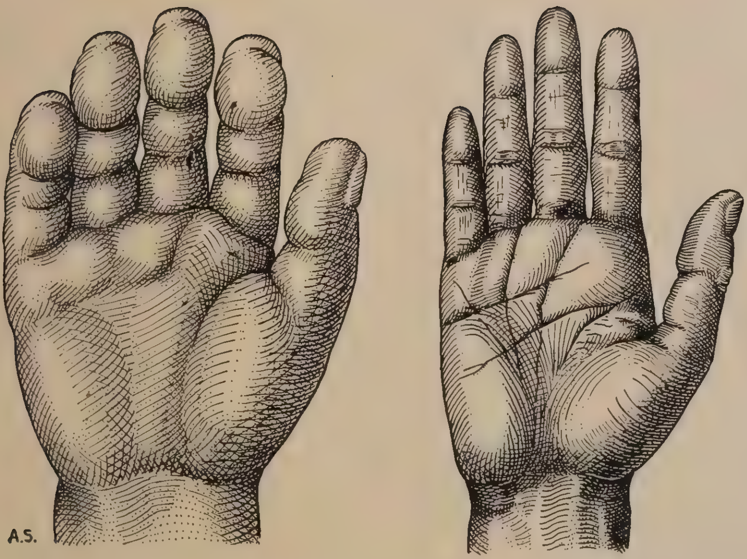

Figure 6. Hand of a human fetus (end of third month) on the left and of adult man on the right, both reduced to the same length.

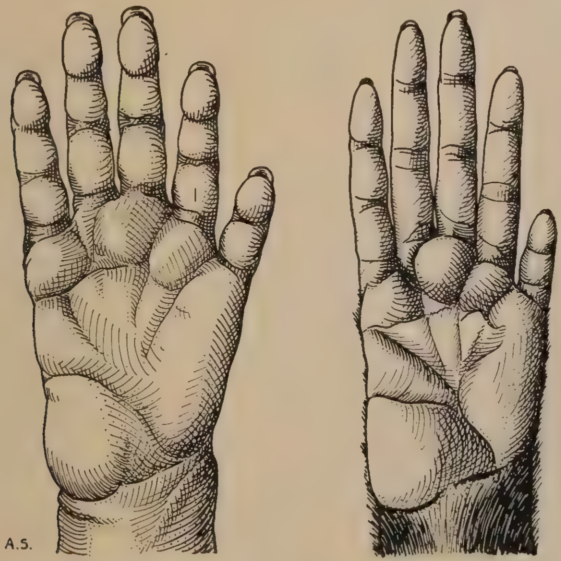

Figure 7. Hand of a fetal orang-utan (145 mm. CR.) on the left and of an adult orang-utan on the right, both reduced to the same length.

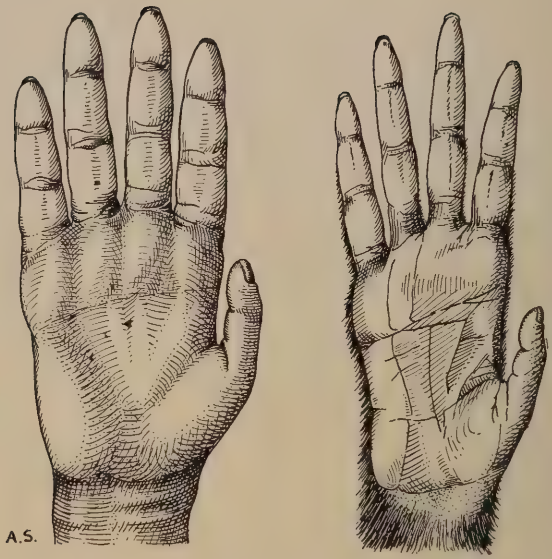

Figure 8. Hand of a fetal howling monkey (Alouaatta palliata) (48 mm. CR) on the left and of an adult of the same species on the right, both reduced to the same length.

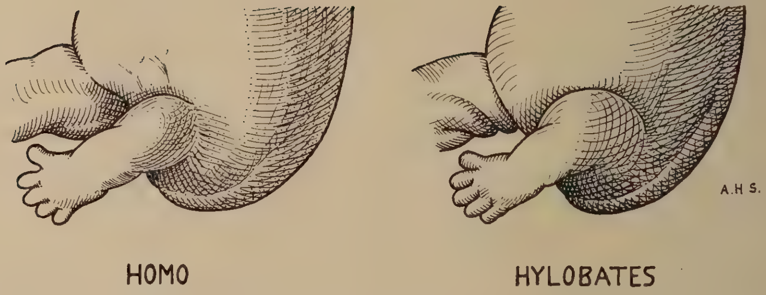

Figure 9. Foot of a human fetus (24 mm. CR.) on the left and of a gibbon fetus (Hylobates concolor) (21.5 mm. CR.) on the right.

the primate hand becomes relatively narrower with advance in growth. Only the baboons, perhaps on account of their largely terrestrial mode of life, show a tendency for a late, secondary increase is the hand index, which brings it in adult life near the upper extreme, which is found in man in his exceedingly broad hand. That the relative hand width is fully as great in monkeys as in man at an early stage of development, i. e., from just before until shortly after the separation of the fingers, is demonstrated by the beautiful illustrations of Keibel (1906) of the outer body form in monkey embryos. This originally very high hand index becomes reduced rather rapidly in all the primates but man, where the decrease with age proceeds more slowly and is less marked.

In all the primate fetuses examined by the author the palmar touch pads had a very similar arrangement, but they seem to fade sooner and disappear more completely in man and anthropoids than in the lower monkeys, especially those of the New World, in which they often persist well marked throughout life.

From Table 6 it can be seen that the length of the thumb is relatively shorter in postnatal than in prenatal life in all primates, with the exception of the baboons, which, after an initial decrease, show a quite marked increase. Cebus and Papio come closest to man, who has the proportionately longest thumb. In other primates the pollex becomes ontogenetically much more reduced, and, indeed (as extreme cases), it has almost disappeared in the African genus Colobus (Fig. 4) and is nearly or completely lost in the American genera Ateles and Brachyteles.

TABLE 6. Relative length of thumb (stylion to tip of thumb in percentage of total hand length).

	Age						
	Prenatal (month)				Postnatal		
Primate	3rd	4th–5th	6th–8th	9th–10th	Infantile	Juvenile	Adult
Homo	74.2	72.5	68.7	68.0	——	——	69.0
Pan	——	——	——	47.5	——	44.3	——
Pongo	——	48.8	52.7–47.6	——	46.2–42.7	40.1	——
Hylobates	——	57.9–56.5	55.9–52.8	50.8	49.0	43.1	49.2
Lasiopyga	——	——	——	54.8	——	——	53.3
Pithecus	——	——	58.4–55.9	56.5	55.0	55.1–50.0	50.0
Papio	——	65.5	62.1–61.7	63.4	62.0–66.7	64.2–67.0	68.3
Cebus	——	72.7	71.8	——	——	70.2	63.1–70.0
Alouatta	66.3	64.6	68.4–65.9	68.1	65.4	60.9–56.1	56.8–56.2
Lemur	——	——	——	66.7	——	59.2	57.6

In the course of growth the attachment of the free thumb to the palm shifts proximally, away from its primary position near the base of the index finger. This ontogenetic migration is most pronounced in orang (Fig. 7), somewhat less in the other anthropoids and man (Fig. 6), and still less in the Old World monkeys, while in platyrrhines no such shifting takes place at all, the thumb persisting in its typically fetal position throughout life (Fig. 8). So far as known to the author, of the many, sometimes widely different, groups of the Prosimiae, several species of Lemur show the same shifting of the thumb as catarrhines and Pocock (1922) reports that in Chiromys the pollex is much farther away from the base of the second digit in adults than in a fetus.

Among all primates, except in a large percentage of white men and perhaps of some other human races, the fourth finger surpasses the second in length. In negroes this rule holds true likewise and since the thumb is proportionately shorter and the hand narrower in the latter than in the white (differences which exist even in early fetal stages) it can be stated that the negro has a more simian hand.

Early in prenatal development the foot of man can hardly be distinguished from the foot of other primates, especially the higher forms (Fig. 9). The author has already briefly discussed most of the main features of the development of the human foot in comparison with the foot of monkeys and apes in his preliminary report on fetal growth in man in this journal (1923), so that here only a few additional points that have a possible bearing on man's evolution, need be mentioned. All these studies are to be published in full at a later date when more detailed proofs for the author's conclusions will be given.

First of all, the erroneus statement by Wood Jones (1920) in regard to the relative length of the toes must be corrected: "Not only is the typical human formula 1 ⟩2 ⟩3 ⟩4 ⟩5 characteristic of the newborn baby, but it is present in all foetal stages from that very early time when the digits first make their appearance upon the limb buds. It is a very noteworthy fact that this peculiar type of foot, which is absolutely distinctive of Homo as a species, should make so early an appearance in the developing embryo. The human embryo does not at any time have its digits arranged upon the primitive formula retained in the monkeys and apes. . ."

In contrast to this the author's observations on many hundreds of specimens show that the digital formula of the human foot undergoes changes in prenatal life; in fetuses of the eighth and ninth week it may still read: 3 ⟩4 ⟩2 ⟩1 ⟩5 and is therefore practically the same as the typical formula for apes: 3 ⟩4 ⟩2 ⟩5 ⟩1; at ten weeks the formula has, as a rule, become altered to: 2 ⟩3 ⟩4 = 1 ⟩5; at twelve weeks it is most frequently in whites: 2 ⟩3 = 1 ⟩4 ⟩5, and not until the eighteenth week does it become characteristic for the white human fetus to show the following formulae: 2 = 1 ⟩3 ⟩4 ⟩5 (44 percent of specimens), and ⟨ 2

1 ⟩3 ⟩4 ⟩5 (40.5 percent), while in negroes of that age it is on an average: 2 ⟩3 ⟩1 ⟩4 ⟩5. In contrast to man this formula seems to remain unaltered during the development in other primates, in which it is to all appearance very constant and uniform. Deviations from the typical formula could only be found in a few platyrrhines, in which the second toe equaled the fourth in length, and in some Prosimiae, in which the fourth toe reached as far as the middle one.

For a short time during the development of the primate foot, just after the digits make their appearance on the foot plate, the toes are united by webs. This webbing persists slightly longer and is more extensive between the second and third toes than between any of the others. Such a web is constant between the second and third toes as far as the second phalanx in adult Siamangs and gave to the latter the name Symphalangus syndactylus. It is very suggestive in this connection that the rare instances of digital skin fusion in adult man occur almost exclusively between these two toes. Since this condition in man is known to be inherited and to represent a local arrest in normal development (Schultz, 1922), it may be concluded that it came about in Symphalangus in an analogous way, i. e., through a hereditarily fixed persistence of a usually temporary embryonic structure.

Table 7 outlines the growth changes in the proportions between the different skeletal elements of the toes. Only the first two toes are considered, since the other toes change in a way quite analogous to the second toe. The first column expresses the combined length of metatarsus and phalanges of the hallux in percentage of the total length of these elements in the second toe, the second column, the relation in length

TABLE 7. Growth changes in some relations between metatarsals and phalanges of the first two toes in man, chimpanzee, and howling monkey. The numbers for adult man and chimpanzee are after Schwalbe (1917).

	Index	$\frac{\text{Ray I}}{\text{Ray II}} \times 100$	$\frac{\text{Phalanges I}}{\text{Phalanges II}} \times 100$	$\frac{\text{Phalanges II}}{\text{Metatarsus II}} \times 100$
Man	Fetus, 10 weeks approximately	81.0	80.0	92.0
	Fetus, 4 months	82.0	87.7	86.0
	Fetus, 6 months	88.8	98.4	81.1
	Newborn	90.0	97.4	73.1
	Adult	90.0	105.7	69.3
Chimpanzee	Newborn	80.9	86.1	93.5
	Juvenile	67.0	64.6	104.3
	Adult	66.3	56.0	126.3
Alouatta seniculus macconnelli	Fetus, 30 mm. CR. approximately	71.0	68.0	81.0
	Fetus, 105 mm. CR.	64.4	59.3	124.3
	Adult	55.1	47.2	135.2

between the phalangeal portion of the first and the second toe, and the third column, the proportion between the phalanges and the metatarsus of the second toe. The most striking conclusion from this table is the fact that all the growth changes in man occur in just the opposite direction from those of the ape and the monkey. This naturally indicates that in the beginning of development these proportions are very much more alike than in subsequent stages of growth. To be more specific, according to column 1 the entire great toe (ray I) increases faster than the lateral toe (ray II) in man, and slower in the ape and monkey. The same is true in regard to the phalanges of these toes (second index), but here the changes are more marked than in the first index. Finally, the third index analyses these conditions still farther and proves that with advancing growth the phalangeal portion of the lateral toes becomes relatively shorter in man and much longer in other primates. Even as widely different types of feet as are found, for instance, in adult man and adult gibbon or howling monkey can be traced back ontogenetically to practically one form (Fig.9), from which their different specializations cause them to grow in opposite ways (Table 7).

So far as the hallux alone is concerned, the writer is convinced that the difference between man and gorilla is certainly not greater than between the gorilla and orang; yet only the first named difference is regarded by some as impossible to bridge. In man the great toe has become strengthened and adduced, both phylogenetically and ontogenetically, while in orang it shows a very marked tendency toward far-reaching reduction, the nail, for instance, in most orangs having already become lost and a single phalanx is not a very rare finding. That the relative length of the "great toe" is much less in orang than in the other anthropoids is evident from the following figures: Greatest distance from tip of hallux to heel in percentage of total foot length: adult man 98 to 100, adult gorilla approximately 88 to 90, adult chimpanzee approximately 80 to 83, adult orang 52.4 (five infantile orangs had an average for this proportion of 59.4, and three older fetuses one of 62.5). Quite analogous to the ontogenetic shifting of the attachment of the free thumb to the palm there occurs in most primates a migration of the point where the great toe is attached to the sole. In embryos and young fetuses the free hallux branches off immediately beneath the base of the second toe; in other words, the cleft between these toes does not reach any farther in a proximal direction. In the course of growth this attachment shifts toward the tarsus. Among the higher primates, this developmental process reaches its greatest extreme in orang-utan, in which the great toe branches off far proximal to the second metatarso-phalangeal joint. Chimpanzee stands next in this respect, while in adult gorilla the relative distance from the base of the second toe to the place of branching of the hallux is very much shorter than in any of the other apes, and in this point again the difference between gorilla and man is less than between the gorilla and orang. In man only does no such migration take place, the attachment of the great toe persisting in its embryonic condition throughout life, similar to the persistence of the thumb in its primary place near the second metacarpo-phalangeal joint which, as stated above, occurs in New World monkeys alone.

That the complete adduction of the human hallux does not come about until rather late in development can be seen from the following notes: In early fetuses the first metatarsal bone is markedly abduced: i. e., its longitudinal axis is not parallel with that of the second metatarsal, as in adult man, but the two axes diverge very considerably. In cleared fetuses (22 to 35 mm. CR.), this divergence in many cases was seen to be fully as pronounced as in some adult apes. On the outer foot this abduction of the first metatarsal in small fetuses causes the great toe to point away from the other toes and also to stand somewhat apart, leaving a fairly broad interval between the first two toes. This abduction of the hallux has to be clearly distinguished from the abduction of the phalanges alone. The latter may not always form a straight continuation of the first metatarsal but may deviate more toward the medial side of the foot; not until the second half of fetal life do the phalanges in rare cases deviate in the opposite direction, toward the second toe. The latter condition may therefore be congenital and not necessarily caused, as has been claimed, by the pressure of shoes.

The metatarsal of the human hallux is much thicker than that of the second toe, and this as early as the end of the second month of prenatal life. In this man does not differ from other primates, since the same was found in small fetuses of several widely different monkeys. Furthermore it was shown by Schwalbe (1917) and by Weidenreich (1921) that the first metatarsal is nearly, or even fully, as much stronger than the second in adult gorilla, chimpanzee, and some lemurs as in man. In young human fetuses metatarsals II to V all diverge forward, a fact which would be anticipated when looking at the broad sole of an early fetal foot with its spreading lateral and medial margins.

Finally, it may be mentioned that the length of the tarsus in relation to the total foot length is considerably shorter in small human fetuses than in adult man. In early monkey fetuses this relative tarsus length is nearly as great as in human fetuses, but, in contrast to man, it decreases during development so that in adult monkey a much shorter tarsus is found than in adult man.

In his paper on the evolution of the primates, Gregory (1916) enumerated the following conditions which would be necessary in order to transform a gorilla-like foot into a human foot: "To increase the length of the hallux, to adduct it and rotate it on its own axis so that its plantar surface shall be applied to the ground instead of facing toward the other digits. Next it would be necessary to shorten still further the phalanges and to narrow the whole foot; that is, to make all the digits parallel instead of divergent, and the whole foot must be 'pronated' or made to face downward rather than inward." In summarizing some of the conditions of development of the human foot, as given here and in the author's last paper (1923), one might say that in order to transform an early fetal foot into the adult foot a number of changes are necessary; to enumerate these would be to repeat, word for word, the points mentioned by Gregory for the hypothetical transformation of the foot of a gorilla into that of man. If it is remembered in addition that the feet of monkeys, apes, and man are very much more alike in a fetal than in an adult stage, it becomes evident that ontogenetic studies strongly support the view that both the human foot and that of other primates developed from one common type, and that in monkeys the adult foot is fully as much specialized as that of man, since the ontogenetic changes, in many instances, are probably greater than in man.

That the eyes of all primates move relatively closer together with advance in growth is clearly demonstrated by table 8. Early in fetal life the relative interocular width is as great as in adults of most other groups of mammals; in human fetuses of nine weeks, for instance, the

TABLE 8. Relative interocular width (interocular width in percentage of bizygomatic width). The figures for the infantile and juvenile chimpanzees are after Hartmann and after Schlaginhaufen.

	Age						
	Prenatal (month)				Postnatal		
Primate	3rd	4th--5th	6th--8th	9th--10th	Infantile	Juvenile	Adult
Homo	44.0	32.0	27.5	25.0	—	24.3	23.0
Pan	—	—	—	21.5	20.7	21.6–20.9	—
Pongo	—	29.3	18.5–15.4	19.1	18.7–11.8	12.2	—
Hylobates	65.7	32.0–25.7	28.5–23.4	24.4	20.7	20.4	23.2–18.6
Colobus	—	25.2	23.6–22.3	22.5	—	20.2	26.6
Lasiopyga	—	—	—	16.8	—	—	15.7
Pithecus	—	—	24.1–18.0	21.5	15.9	16.7–15.2	15.6
Papio	—	26.8	20.9–19.0	18.3	15.6–15.3	15.1–14.7	17.9
Cebus	—	24.5	24.6	—	—	19.2	17.5–16.3
Alouatta	30.7	29.2	26.7–26.5	25.3	23.3	22.6–22.2	21.1–19.3
Lemur	—	—	—	48.3	—	46.4	44.8

distance between the inner angles of the eyeclefts still amounts to over half of that between the zygomatic arches. Man does not occupy a separate place in this feature of development, but stands at any age well within the range of variation in the approximation of the visual organs exhibited by his simian relatives. Of these the Prosiminae retain by far the most original and therefore relatively widest interocular space, while many of the monkeys, and the orang particularly, have progressed to a higher specialization in this regard than man, whose interorbital septum is comparatively broad.

With these few and scattered observations on the relation of the growth of primates to man's evolution, which really grew out as biproducts from studies on the development of the human fetus, it is hoped to have at least stimulated further investigations and thought—perhaps criticism—in this promising field. It probably has occurred to the reader that the author has applied the recapitulation theory not always in its safest and most conservative interpretation; this is due to the fact that he could not convince himself that such highly limited argumentation is in every case a logical necessity. Even if one does not concur with the latter view, there will remain the forcible conclusion that the many striking resemblances between man, ape, and monkey in early development, and their frequently closely corresponding growth changes can only be explained by one common origin, from which they all inherited the tendency for the same ontogenetic processes which could only become modified through later specializations. A further general conclusion, which the author considers as safe, is that man in some respects is less specialized and has hence remained phylogenetically as well as ontogenetically more original and "primitive" than various other primates.

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RACIAL DIFFERENCES IN THE PAPILLARY LINES OF THE PALM

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ACKNOWLEDGMENTS

The nucleus of the present article was a study on some racial differences in the papillary lines of the palm that was made by the writer as part of a thesis for the doctorate at New York University in 1917–18. Since then, the acquisition of more material has led to the rewriting of the paper with a more comprehensive view-point, a clarification of theory, and the weeding out of what proved to be non-essential.

The reproduction of hand-prints in the present article has been limited by considerations of expense; but practically the entire collection of original prints has been committed, at least temporarily, to the keeping of Dr. Aleš Hrdlička of the U. S. Museum, for whose interest in the publication of the present article, the author gives grateful acknowledgment.

Thanks are also due to the Faculty of the School of Pedagogy of New York University, especially to Dr. Paul Radosavljevich, for valuable guidance and encouragement in the undertaking of the investigation.

The author is also appreciative of the confidence of the many people of various races who have cheerfully "lent their hands" for the purposes of this study. Among those who gave invaluable assistance to the writer in gaining access to material, were Mr. R. Tsunoda, Director of the Japanese Schools in Hawaii; Mr. J. L. Hopwood, Chaplain of the Kamehameha School of Honolulu; Dr. A. Akana, pastor of the Hawaiian Mission Church of Honolulu; Mr. B. F. McKapagal and Mr. C. C. Ramirez, President and Secretary respectively of the Filipino Y. M. C. A., Honolulu; Miss Sadie C. Sterritt, Supt. of the Girls' Industrial School of Hawaii; the capable Head Worker in the Corean Mission Home for Orphan Children, whose name the writer has unfortunately forgotten; Mr. G. S. Raymond, Inspector-General of Public Schools in the Hawaiian Islands; Mr. Daniel Robles, whose friendly introductions secured for the writer the assistance of Dr. Luis E. Valcarcel of the University of Cusco and of Mr. J. Patron-y-Castro, student of the University, who

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gave unstinted service in the taking of the handprints of the Cusco Indians.

For lightening the difficulties of travel in remote places, for acting as interpreter in Spanish-speaking countries, for co-operation in the taking of the hand-prints at all times, the writer is deeply indebted to her friend, Miss Elena H. Klasky.

FOREWORD

The author does not consider the conclusions of the following article in any sense final. The material at hand was too scant in many instances to yield anything more promising than suppositions. Yet it is hoped that these suppositions will prove promising enough to stimulate many investigators to collect vastly more extensive data. The labor of doing so is not very great. All that is needed is belief in its value. It is hoped that the present article will supply this incentive.

The attempt is here made not only to disclose the *facts* of racial difference in the papillary lines of the palm, but to discover, if possible, the *functional meaning* of the facts. Needless to say, the pursuit of both these aims reacted favorably one on the other. Perhaps the most outstanding fact, and the one most discouraging to the seeker after racial differences, is the great similarity, in general, of all human palms. Yet the similarity in this feature is no more remarkable than that in any other human feature. In the midst of this general similarity in palm formation, is a tantalizing individual variability that again and again throws one off the trail in the pursuit of prevailing racial tendencies, and forces the feeling that the goal is elusive, like an *ignes fatuus*. As in racial psychology, no generalizations can be made that do not do violence to individuals. Yet the broad fact of racial difference is undeniable. Without the morphological principles established chiefly by Kollmann, Klaatsch, Féré, Wilder and Schlaginhaufen, it would be futile to attempt to place the emphasis upon this, that or the other feature as significant functionally. And without functional significance, anatomical significance is nil.

The author's previous study of left-handedness and ambi-dexterity in relation to the papillary line systems yielded an important principle of interpretation that has interesting confirmation in the present study. The characteristics of the dextrous hand become an index of racial achievement. Chief among these characteristics is the position of the carpal "Tri-radius" (to use Wilder's term). It is nearer to the thumb in the dextrous hand, suggesting a broader development of the ulnar system of the lines. There ought to be a relation made out between the position of the carpal Tri-radius and the meeting ground of the arborizations of the ulnar and radial nerve-trunks of the arm as they ramify over the palm. Dexterity seems conditioned not only by radial development as in the opposition of thumb to fingertips, but also by a strengthening of the ulnar muscles. One has only to observe the posture of an efficient hand in contrast to that of a weak and flabby one to realize the part played by the opposition of the last two fingers to the ulnar prominence of the palm.

It is hoped that none of the conclusions of the present article will be construed as favoring the doctrine of superior and inferior races. As Boas has clearly demonstrated, the stages of civilization reached by different peoples of the Earth are due rather to different material and social environmental factors than to any great inherent differences of capacity.

Such studies as this should throw light on racial relationships or ancestry where language and customs are no guide. The effect of racial mixture proved a very interesting feature of the present study, although the data at hand were all too inadequate. The difficulty of procuring "pure-blooded" types or of knowing how "pure-blooded" they are is counter-checked by a knowledge of what to expect of racial mixtures. Here, as everywhere, numbers are the best safe-guard. The papillary line-conformation is to be viewed as much older in evolutionary time than language, customs or stature, or, hypothetically, color. How old it is can only be appreciated by following its morphological history. That is why it shows so many atavisms. The fact that racial differences do exist would indicate an almost unthinkable length of time during which they have been developing.

RACIAL DIFFERENCES IN THE PAPILLARY LINES OF THE PALM

For purposes of description and comparison, some system of mapping the palm must be employed corresponding to that recommended by Galton for the classification of finger-prints. For the papillary lines of the palm, no scheme could be better than that devised by Dr. Harris Hawthorne Wilder, of the Department of Anthropology of Smith College. Not only is it simple and serviceable, but it is free from the artificiality that characterizes Galton's "types" and "varieties" of finger-tip patterns. While Galton's categories have proved themselves equal to the task of identifying persons, they bear no demonstrated relation to factors in the evolution of the papillary ridges. Wilder's palm "formulae," on the contrary, can be shown to stand in intimate relation to the morphological development of the skin-ridges themselves as well as to the functional evolution of the hand.

Galton's "Finger Prints," however, published in 1892, stimulated many investigators who endeavored to arrange the finger-tip patterns in a developmental series, for the purpose of detecting marks of atavism in the degenerate, the criminal and the insane. D'Abundo, Ruggeri Féré, Sancta de Sanctis and Toscano gathered finger-prints from hospitals, prisons and alms-houses, as well as digital impressions of the lower monkeys and higher apes,—a field that had been explored, though for a different purpose, by great anatomists and morphologists as far back as Purkinje[20] (1823). The practical result of all this labor of the criminologists and pathologists was quite disappointing. Finger prints had no certain diagnostic value. It appeared, however, that Galton's so-called "primary type," which approaches the transverse parallel arrangement of the ridges, should doubtless be placed at or near the end of the developmental series. The true primitive type, found in the lower monkeys, is a fascicle of lines running longitudinally, slightly divergent, and enclosed by ridges in the form of an arch and by the transverse ridges at the base. (See Fig. 2b.)

In truth, investigation of the form of the patterns themselves has yielded very little of direct value to anthropology. It was only where the number and variety of patterns and their location and symmetry in the two hands were made the subjects of investigation that any important hypotheses were derived. In a study of 182 epileptics, Féré found that the tendency to variations in patterns diminished from the thumb to the little finger. He found fewer varieties of patterns on toes than on fingers. "In short," says Féré, "all the researches point to the conclusion that when the different fingers of the hand are compared, or when toes are compared to fingers, variety and morphological complexity correspond to variety and complexity of function." As to symmetry between the two hands, D'Abundo (1894) with the finger-prints of 140 criminals, found symmetry increasing from thumb to little finger. Féré's study of symmetry also showed that those fingers of both hands are most frequently symmetrical which evidence the least tendency to variation.

While the medical and criminal anthropologists were seeking signs of atavism and degeneracy in finger-tip patterns and in bodily malformations, attention was diverted to the more popular finger-prints away from the palm and its papillary markings—a field in which the anatomists and morphologists had shown an interest for a generation, under the stimulus that had been given to all scientific research by the gradual perfection of the compound microscope and the publication of Darwin's great theory. Purkinje, in 1823, had studied the lines not only in the palms of apes but also in the prehensile tails of South American monkeys. Alix,[1] in 1868, in a treatise on the palms and soles of Primates made careful drawings of the papillary markings before the art of photography made it possible to reproduce them easily and faithfully. He compared the position and form of the "patterns" of a whorled or looped shape, occasionally found in the palm of man, with those invariably found in the palm of the ape. Kollmann[16] (1883) studied the position of the "touch-balls" or pads on the palms and soles of monkeys and noted the curious coincidence of the presence upon them of specific papillary line patterns. He further pointed out that these spots were richer in skin nerves and touch corpuscles than were the intermediate regions. Klaatsch[15] (1888) compared the plantar and volar structures of man and apes with those of other animals.

Meanwhile, the histological structure and development of the papillary ridges had received careful treatment at the hands of Remy[21] (1878), Kollmann[16] (1883), Blaschko[2] (1884–87), Unna[27] (1888). According to Blaschko, the pre-natal development of the epidermal ridges does not go on all at once over the whole palm and sole, but begins on the finger and toe tips, about the fourth month, after the volar and plantar balls are fully grown. The lines advance from the periphery of the pad to the centrum. The development of the ridge is effected, first, by the growing epidermis sending downward the proliferations that bear the sweatglands and their coiled ducts. In the next stage, the outer surface forms a low ridge over each of the rows of sweat-glands. While these superficial ridges are forming, there are formed on the dermal or under side of the epidermis, secondary ridges much smaller than the first and underlying the grooves separating the external ridges. Into these grooves on the under surface of the epidermis fit the tactile papillae of the cutis in which are embedded the nerve-endings of touch. One can see how a vertical or sidewise pressure on the skin-ridges would disturb the nerve corpuscles.

Nearly a decade after the publication of Galton's work, Féré[6] turns from the somewhat disappointing finger-tip patterns to the papillary markings of the palm, still seeking signs of atavism. He notes that the papillary ridges follow in general a direction in keeping with the deep flexion folds of the hand, and that patterns are prone to appear in the interdigital spaces where the skin is more mobile. He refers to an article by Wilder in Anatomische Anzeiger of 1897 which stressed the homology between the location of papillary line patterns in the primates and the pressure pads in the feet of pentadactylous animals. Féré scouts the "pressure theory" of the formation of patterns citing the fact that on the part of the human sole on which the greatest pressure is exerted, viz., the heel, patterns never appear; nor are they found where callous places form in the hands of the manual worker. He considers that the friction (*glissement*) of one part of the skin against the other during movements of grasping or manipulation is sufficient to engender a disposition of the papillary lines in looped or concentric patterns, or to establish opposing directions in systems of lines. In an earlier article, Féré[4] described a neat experiment wherein a piece of transparent glass was grasped between the inked thumb and finger-tips with the result that the lines imprinted on the opposite surfaces of the glass were seen to lie in directions nearly at right angles to each other. The gliding of such skin surfaces over each other, as is done customarily in "feeling" with the fingers would tend to subtler touch discrimination.

A "friction theory" similar to Féré's had been advocated by Hepburn[12] (1895), who used as his strongest argument the fact that in the prehensile tails of monkeys the papillary ridges lie transversely, so that in the act of prehension they are parallel to the branch or other cylindrical object grasped, thereby opposing their full length to the direction of possible slipping.

The apparent inconsistency of the "pressure" and the "friction" hypotheses disappeared in the light of an exhaustive study of the whole problem of palm and sole configuration undertaken by Dr. Wilder in collaboration with his pupil, Inez Whipple,[28] (1904). They reviewed, with a wealth of illustration, the entire field of simian and pro-simian chiridia, and traced the morphological development of papillary skin-ridges from their first appearance in mammalian orders to their final state in the primate palm and sole. They proved that the cores of patterns on the primate hand actually represent the pads on the soles of walking mammals, even though the pads themselves as prominences may have quite disappeared in the primate palm. The only mammals to show a suggestion of papillary ridges on the summits of the pads, until we come to the monkey, are some species of marsupials and of rodents. In the walking mammals the pads relieve the shock of concussion with the ground, and to that extent their touch function, and hence the need of papillary ridges, is at a minimum. In the climbing animals, the pads assist definitely in prehension, especially in the absence of claws, while they continue to support the distal arch in walking. As prehension comes more and more to supplant walking as a method of locomotion, the pads flatten and tend to merge with neighboring pads. At the same time the papillary ridges which at first covered only the summits of the pads now extend to cover the entire surface of the palm, as more and more of this surface is brought into contact with the grasped object. Thus we come to the flat homologous surface of the anthropoid palm and sole, with the patterns persisting in the same anatomical areas that had carried the pads.

If the normal human palm does not show the extreme flattening of that of the anthropoid ape, it is because the superior development of the muscles that move the thumb and little finger has created the rounded thenar and hypothenar eminences that give character and shapeliness to the human palm. These are not due to the presence of abundant fibrous and fatty tissues, which are responsible for the balls or pads on the monkey palm. The powerful arm muscles give the gorilla its tremendously strong grip; the thumb is relatively weak. The skin along the deep opposition folds in the palm of man and apes is attached to the compact connective tissue belonging to the palmar musculature. Only in individuals with much adipose tissue does the palm of man present tiny "mounts" at the base of the interdigital spaces.

Confirmation from embryology of the evolution and effacement of the pads in the human foetus has not been wanting. Johnson[13] (1899) observed on the palms of human foetuses of two or three months three true interdigital mounts in a transverse line, the thumb-index-finger elevation being represented by a large thenar eminence. Retzius[22] (1904) studied the progressive development in a series of embryos of the balls in palms and soles: When the embryo has reached the length of 152 mm., the interdigital mounds begin to be effaced, whilst the muscle pad at the thumb base and that at the ulnar margin remain strongly developed.

The year following the appearance of Wilder and Whipple's treatise, Schlaginhaufen[24] of Zurich published an extensive study, with original contributions touching every phase of the subject of the skin-line systems of the primate palm and sole, with a valuable bibliography. He includes interesting psychological experiments on touch-discrimination as related to the looped patterns of the finger-tips. He thinks more studies should be made on the movements of walking, swinging and grasping characteristic of different species of ape. He correlates the slow, deliberate movements of the anthropoids with the absence of pads, while the rapid swinging from branch to branch on the part of the monkey is assisted by the presence of pads in making for security of grip. The pads, therefore, have a function other than touch.

Included in Schlaginhaufen's original material were the prints of the soles of individuals of many different races and tribes, comprising Papuans, Negroes, Japanese, Chinese, Indian, Battak, Javanese, as well as a large number of Europeans. His effort at that time, however, was not the discovery of racial differences, but was doubtless prompted by the desire to secure as varied a representation of the human species as possible. Kollmann[16] (1883) had been the first to draw comparisons between the different races in regard to epidermic markings, but he had too few subjects, making his attempts entirely futile. Galton had compared the finger-prints of English, Welsh, Jews, Basques and Negroes. The results were negative—the differences between groups of different races being not larger than the differences between individuals of the same race.

The pioneer study on racial differences in the papillary lines of the palm that brought out-standing results of great value was achieved by Wilder[31] with a set of hand-prints of American Negroes collected by Miss Inez Whipple at Providence, Rhode Island. The results were published in the American Anthropologist for April, 1904. This study was quickly followed by another, published in the same Journal in June of the same year, on the hand-prints of 22 Maya Quichi Indians of Yucatan. Dr. Wilder acknowledges indebtedness for these hand-prints to Dr. Tozzer of Harvard University. The results of this study, though based on so few individuals, are highly interesting because of certain features that differentiate them strikingly from either Negroes or Whites. (All of these results I wish to bring into comparison presently with my own.) Following the lead of Wilder's studies, Schlaginhaufen[25] (1906) and Loth[18] (1911) took up the task of extending the investigation, the former making a study of the natives of Farther India and Ceylon; the latter, of Polish peasants from the secluded districts of Kielee and Lublin of Russian Poland. In 1913, Wilder[32] was able to confirm the conclusions of his study of American Negroes by means of palm and sole prints of 100 native soldiers of 13 different tribes of Liberia and Sierra Leone, obtained for him by Prof. Fred. Starr in an expedition to Africa the year before.

My own studies, which prompted the present article, are on the palm-prints of 100 Japanese, 32 Koreans, 43 Filipinos, 29 Hawaiians of pure blood (as far as could reasonably be determined), 75 Hawaiians of mixed blood,—(all of these, taken by me in Honolulu in 1917)—, 33 Aymara Indians of Tiahuanaco near Lake Titicaca and 28 Kechwas (Quechuas) of the vicinity of Cusco, Peru, taken by me in August, 1923.

From first to last, all of these inductive studies of racial differences would have been impossible of accomplishment without the categories established by Wilder's method of mapping the palm and their convenient expression in the palm "formulae." The first conception of this method appeared in an article by Wilder,[30] entitled "Palms and Soles," in the American Journal of Anatomy, 1902. The crux of the method consists in the fact that the emphasis is shifted away from the "patterns" in the palm and centered upon the boundaries of the areas where patterns morphologically belong, whether the patterns still exist on those areas or not; for the reason that the reduction or disappearance of patterns has been coincident with the flattening, spreading and consolidation of the pads, while the papillary lines that had originally developed only on their summits have little by little extended to cover the whole palm.

As pads flatten and consolidate and papillary ridges lose their concentric arrangement in favor of a more parallel arrangement, there is another factor that will determine the direction of the resultant systems of parallel ridges over the entire palm. It has to do with the development of the muscles and the particular method of flexing or opposing the thumb to the other digits. Naturally these two factors are in close causal connection, but we will consider each separately. The first factor brings us to the scheme for mapping the palm devised by Wilder:—

Glancing at the palm-print of Macacus Rhesus (Fig. 2b.), we note the places where pads and their surmounting patterns occur. In general, they are around the margin of the palm, occupying the four interdigital spaces (termed 1st, 2nd, 3rd and 4th) and the ulnar or hypothenar region near the wrist. The weak thumb base shows no muscular eminence, and no thenar pad separate from the 1st interdigital, such as appear in Gelago, Tarsius and other species. Looking now at the human palm-print (Fig. 1), we observe a little below the base of each finger, a point where adjoining interdigital pad-areas have met each other, and both have met the transverse system of finger-ridges that have impinged on the palm proper in a little V-shape. These points are called by Wilder "Tri-radial Centers," because three papillary ridges radiate from each one of them. Two of the radiants, in each case, form the V just mentioned. The third radiant is longer and may be traced across the palm to its terminus in the margin. There are thus four of these

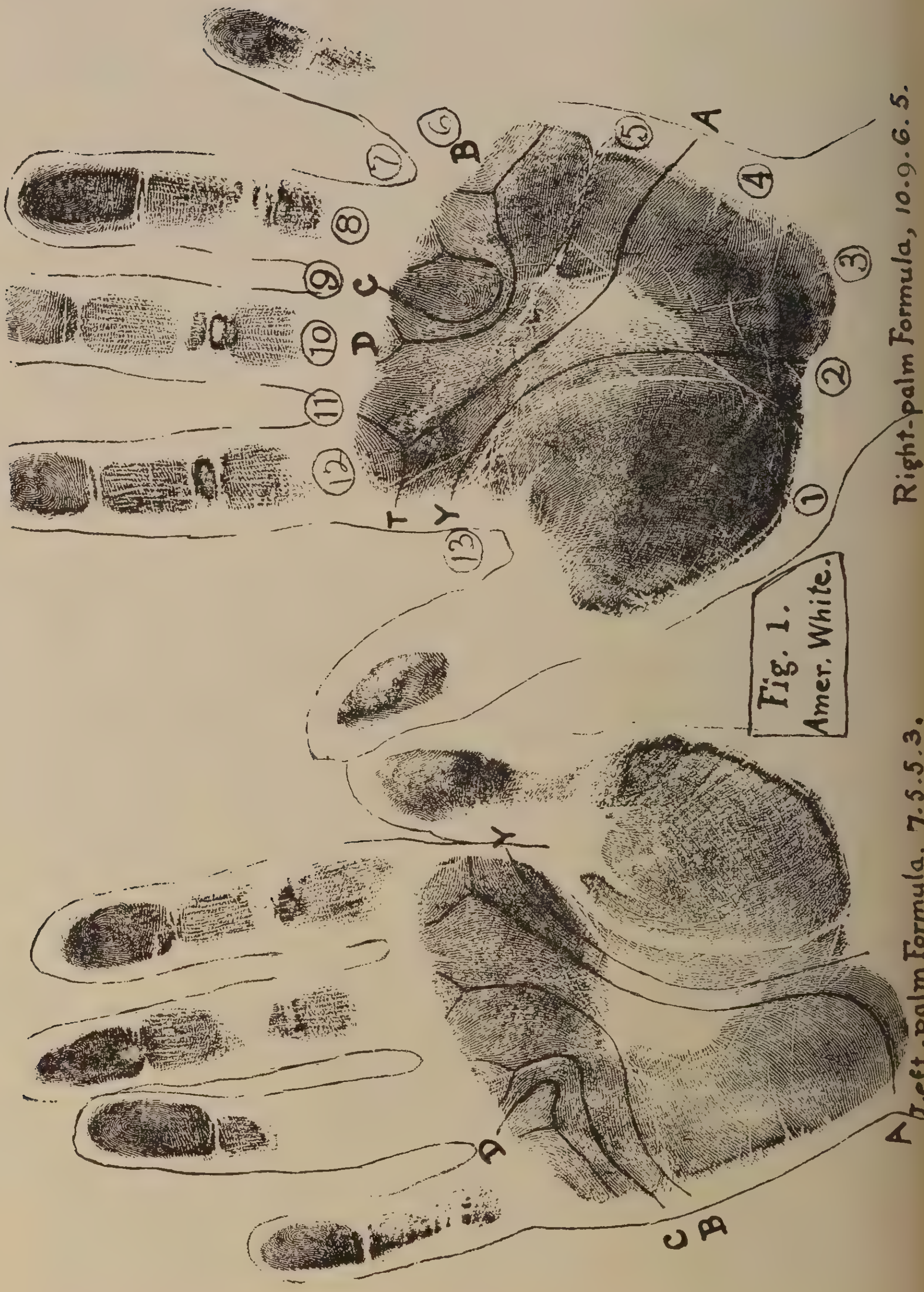

Fig. 1. Amer. White.

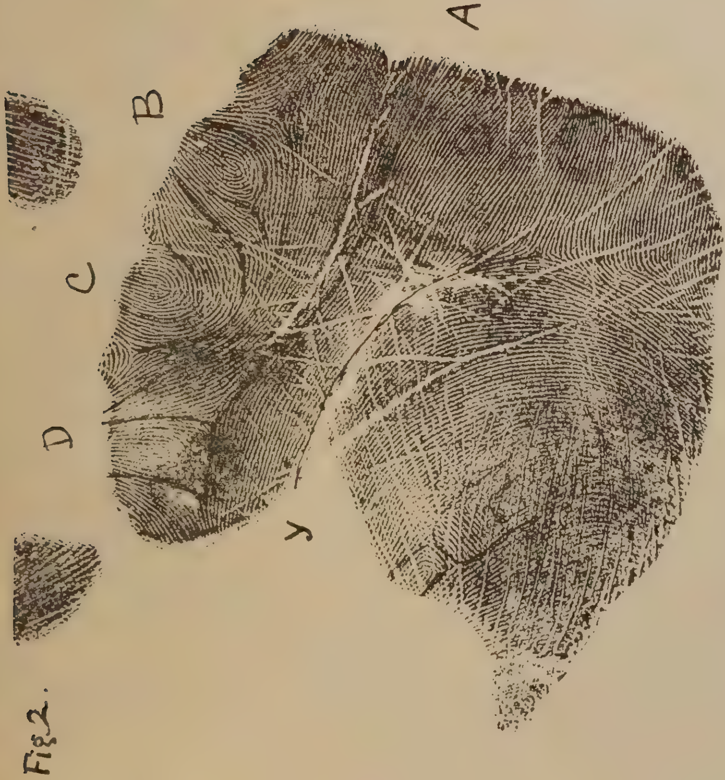

FIG. 2—(Amer. White)—Right palm.—Compare location of looped and concentric patterns with those of FIG. 2b.

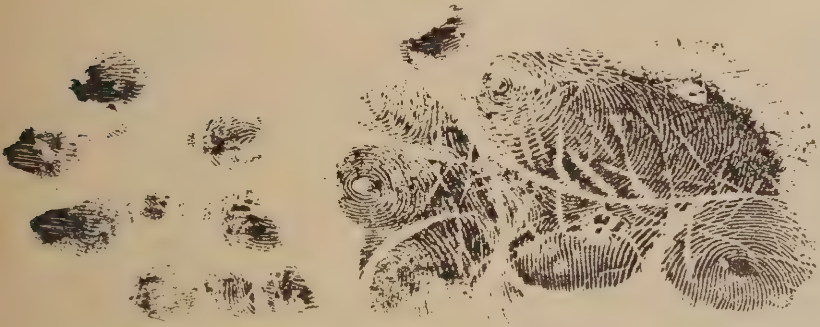

FIG. 2 (*b*)
Left palm, *Macacus rhesus*

longer radiants, one emanating from the base of each finger. These four lines are called by Wilder "Main Lines," and are designated by him A, B, C, D, in the order of the fingers, beginning with the index-finger. They mark the confines of the original pads which in phylogenetic development have flattened, spread and consolidated, their papillary ridges adapting their direction as best might be to that of neighboring lines. (Fig. 2 shows the palm-print of a college student that retains all the patterns on these amorphic pad areas, excepting on the hypothenar pad.)

The "Formula" of the palm, as devised by Wilder,[33] is an ingenious method of describing the course of the Main Lines by indicating in what part of the margin of the palm each one terminates. For this purpose, the palm-print is treated like a dial, and figures from 1 to 13 are ranged around it as follows:—1, where the thenar region meets the wrist; 2, at the carpal center; 3, at the hypothenar region contiguous to the wrist; 4, at the side of the hypothenar region*; 5, at the ulnar side of the hand in the neighborhood of the flexion fold; 6, at the base of the little finger; 7, in the fourth interdigital space; 8, at the base of the third finger; 9, in the third interdigital space; 10, at the base of the middle finger; 11, in the second interdigital space; 12, at the base of the index-finger; 13, in the first interdigital space, i. e., between the thumb and index-finger. The palm formula for the left hand in Fig. 1. is 7.5.5.3. and that for the right hand is 10.9.6.5. The four figures in each case locate the termini of the Main Lines, D, C, B, A, in the order named. It will be seen that the lines of the right hand are pushed upward, that is, in the direction of the higher figure in the margin of the palm, in this case to the extent of giving a higher formula to the right hand.

This curious difference between the two hands, so characteristically human, is perhaps the most remarkable and significant fact revealed by the study of extensive and varied collections of human palm-prints. Wilder and Whipple were the first to make note of the phenomenon, in their earliest studies on racial characteristics. Miss Whipple says, speaking of the Mayas: "The right hands are seen to be considerably in advance of the lefts in the characteristic human tendency toward a crowding of the ridges upward toward a horizontal position." With

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*Wilder limits Position 4. to those cases where Line A terminates in a pattern on the hypothenar area. I have not done this, as it seemed to me more important that the palm formula should indicate the *direction* of the main papillary lines than the fact of the presence of an hypothenar pattern. Besides such patterns appear in all stages of degeneration, down to zero.

every race studied, the same feature, to a greater or less degree, forces itself on the attention of the investigator.

In order to verify a strong supposition that this asymmetry of the two hands in the direction of their papillary ridges represented a functional difference between them, I collected 90 hand-prints of as many left-handed persons. In an as yet unpublished study, I have shown that the relation is reversed in their case: It is the left hand that presents a higher position of the papillary lines, or else (in about 33% of the cases) a condition of symmetry between the two hands. One is reminded of the tendency to ambidexterity in left-handed people. The proof afforded of the inherited nature of left-handedness is obvious,—a question that has been in much dispute, and has recently been pronounced unsettled by a leading psychologist. In any large group of hand-prints, of a chance selection, one will find from two to four per cent showing a lower formula or lower positions of the main lines in the right hand than in the left. This is the recognized percentage of left-handedness in a given population.[11,26] The Main Line in the palm that is the most invariably indicative of unidexterity emanates from the tri-radial center in the carpal region of the palm, where the transverse lines of the wrist meet the thenar and hypothenar lines at their point of confluence. Sometimes this point is so far down on the wrist as not to appear on the palm-print, but is represented by a parting or divergence of the thenar and hypothenar line-systems. From this point, a line traverses the palm running parallel to the thenar system of lines, and ending in the first interdigital space (usually). This line is mentioned by Wilder, but is not included in his palm formula. In the dextrous hand, it runs nearer to the thumb than in the non-dextrous hand. I have labeled this line, "Y". In comparing the right and left hands, it is convenient to note the distance between the marginal terminus of "Y" and that of the short radiant "T" running from the Tri-radial center of the index-finger. This distance is greater in the dextrous hand. (See Fig's 3, 4, 5 and 6.)

While the Main Lines, as described by Wilder, including the one just mentioned, can be thought of as marking the boundaries of pad areas now flattened and consolidated, there is another factor, already alluded to, that has determined their direction in the palm: It is the muscular development of the hand and its modes of flexure—the factor stressed by Féré[6] and Hepburn.[12] As the thenar and first interdigital pads are replaced by the strong muscular cushion of the thumb, the thenar papillary lines assume a direction parallel to the deep flexion-fold of the

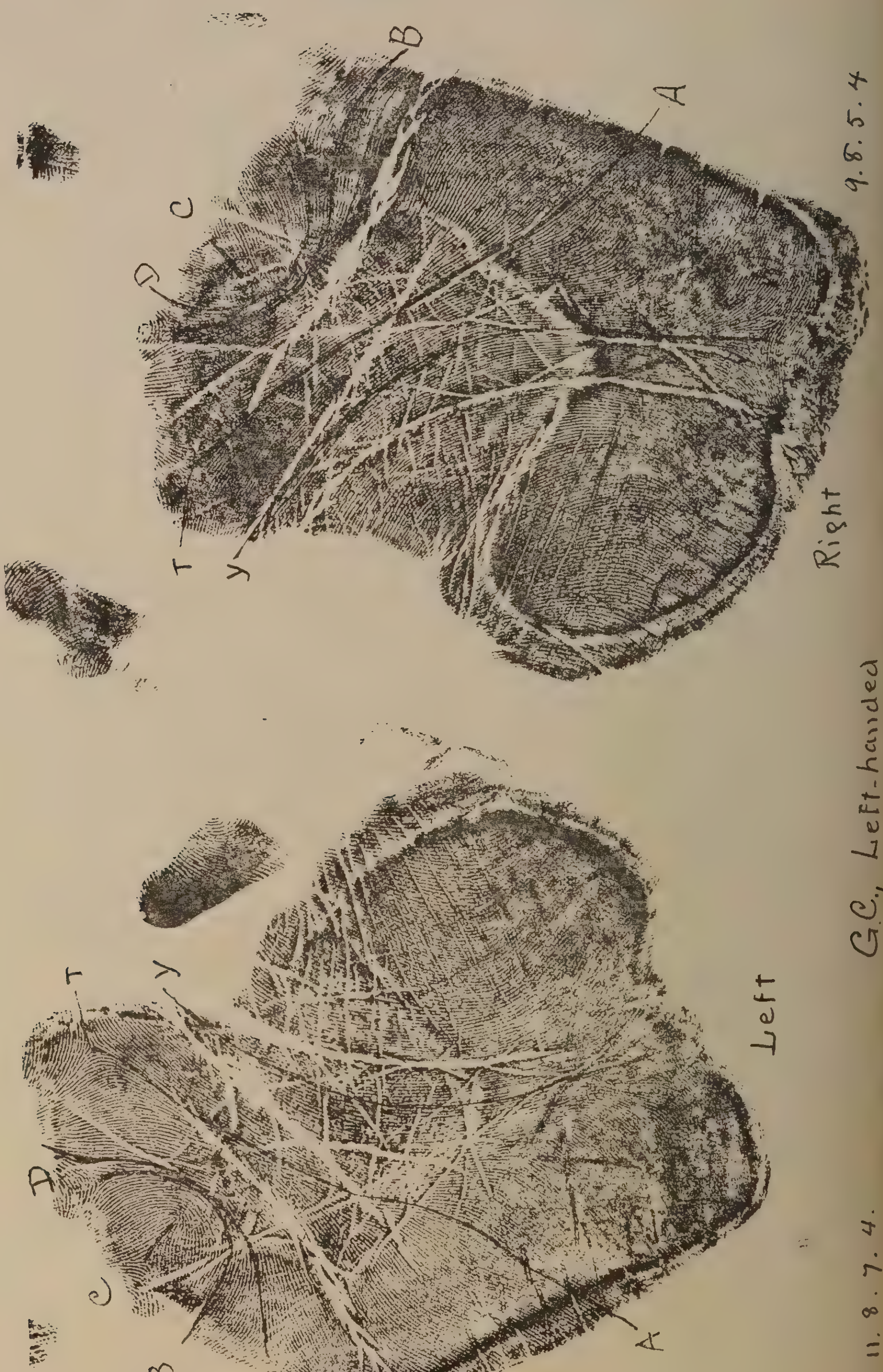

FIG. 3.—(Amer. White.) Note higher formula and greater distance between T. and Y. in left palm than in right.

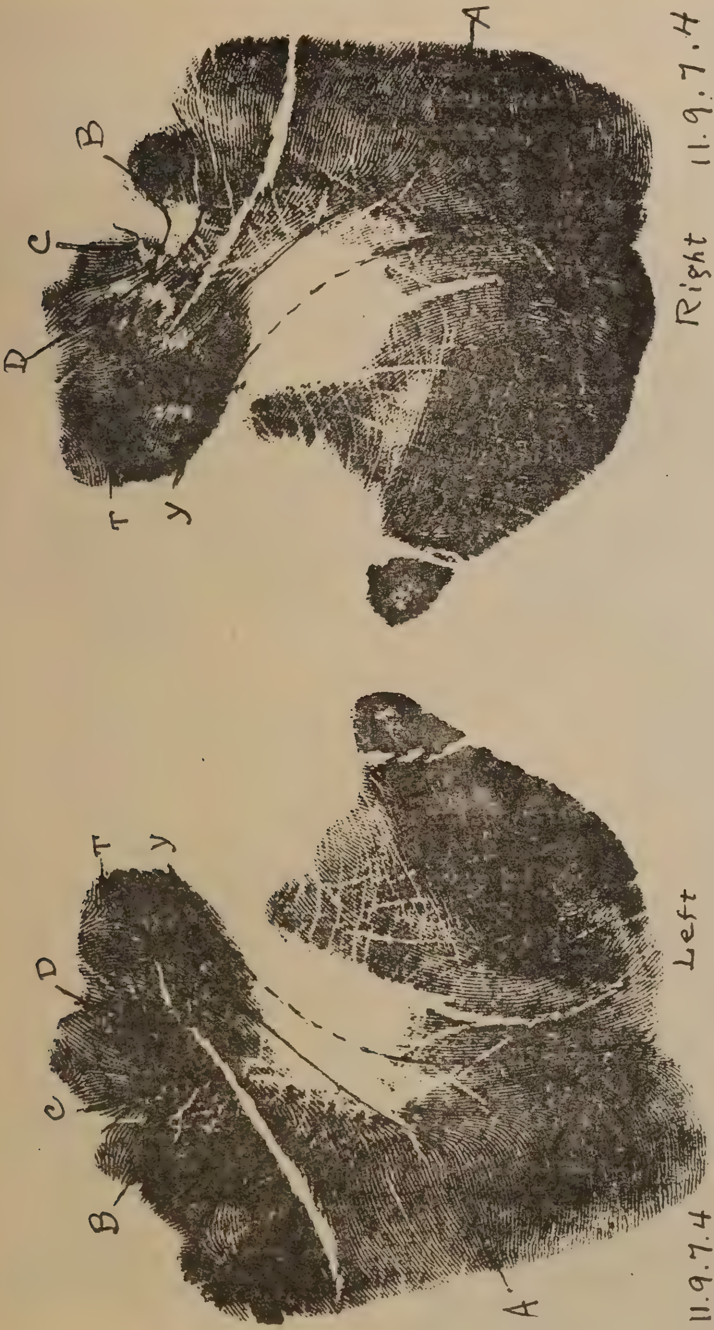

Fig. 4—Amer. White, ambidextrous. Note symmetry of lines in right and left palms.

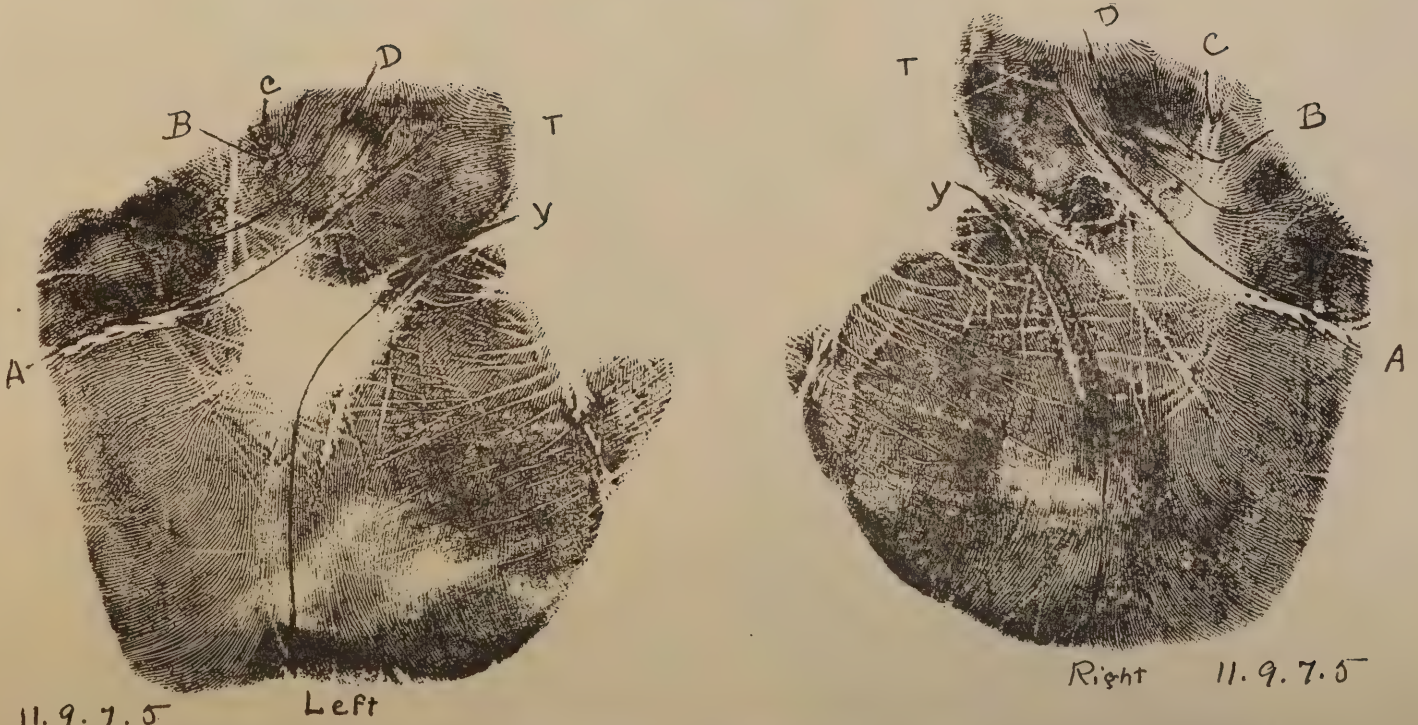

FIG. 5—Twin sister of Subject, *Fig. 4*. Right-handed. Note greater distance between T. and Y. in right hand than in lft.

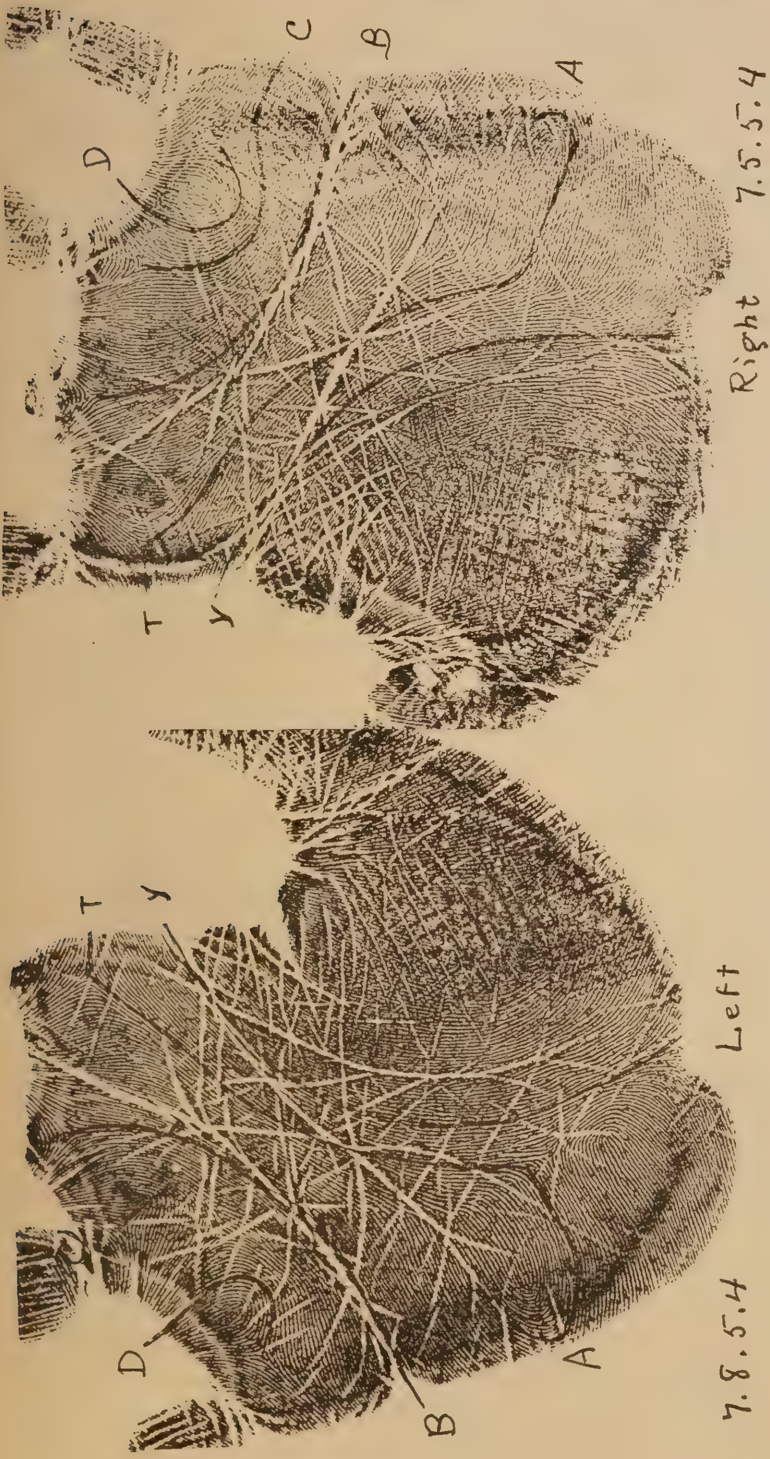

FIG. 6—Amer. White, Left-handed.

thumb. (In the palm-prints, the flexion-folds appear as broad white lines.) The four fingers have a common flexion-fold which meets the flexion-fold of the thumb at one end, but which does not run clear across the palm transversely as it does in the monkey palm, because of the human tendency to oppose the thumb to all the fingers. The common flexion-fold is replaced, therefore, before it has reached the ulnar margin of the hand by the special flexion-fold of the last three fingers. The monkey palm lacks entirely (Fig. 2b.), this special flexion-fold. It possesses the transverse and longitudinal folds, sunk between the interdigital pads, which arise from its folding of the fingers in a hook-like manner as well as from its habit of folding the radial side of the palm against the ulnar throughout its whole length. A vestige of this long longitudinal fold is found in the human palm.

Since these two types of folding, the transverse and the longitudinal, are the prevailing ones in the monkey, we find the bounding papillary ridges of their pattern or pad areas assuming quite boldly a vertical or a horizontal direction. For a similar reason, in the human palm, the papillary lines adopt a *sloping* course in keeping with the diagonal flexion-folds. In the center of the monkey palm, is found a tri-radial center where the vertical and horziontal line-systems meet. This is represented in the human palm by the spot where the papillary lines begin to fan out as they run towards and cover the ulnar prominence. Line A. is the representative line for this whole diagonal system. Likewise the positions of the lines B, C, and D have been determined by the tendency of the lines to parallelism with the finger flexion-folds as the interdigital pads gradually flattened and merged.

In practically all the *right* hands of human beings of all races, Line A pursues this diagonal course across the palm, terminating at the margin in positions 3, 4 or a low 5. In the *left* hands, however, very interesting racial differences appear: Wilder first observed this in his study of the Maya Indians. In the right hands, he found the formula 11.9.7.5. to be the commonest formula, while in 25 % of the left hands, Line A ended below the free margin of the hand. This would mean Position 1, 2, or low 3. In the Hawaiians, I have found this very low position of Line A in 23 out of 29 left hands, and but once in the right. Likewise the Aymara and Kechwa Indians of the Andean Plateau show respectively 39% and 52% of these very low terminations of Line A in the left hands, and but 3% and 0% in the right. On the other hand, in the Whites, this condition is found in only 12% of left hands and 4% of right hands. In the Japanese and Filipinos, it is found in 20% and 18%

Fig 7

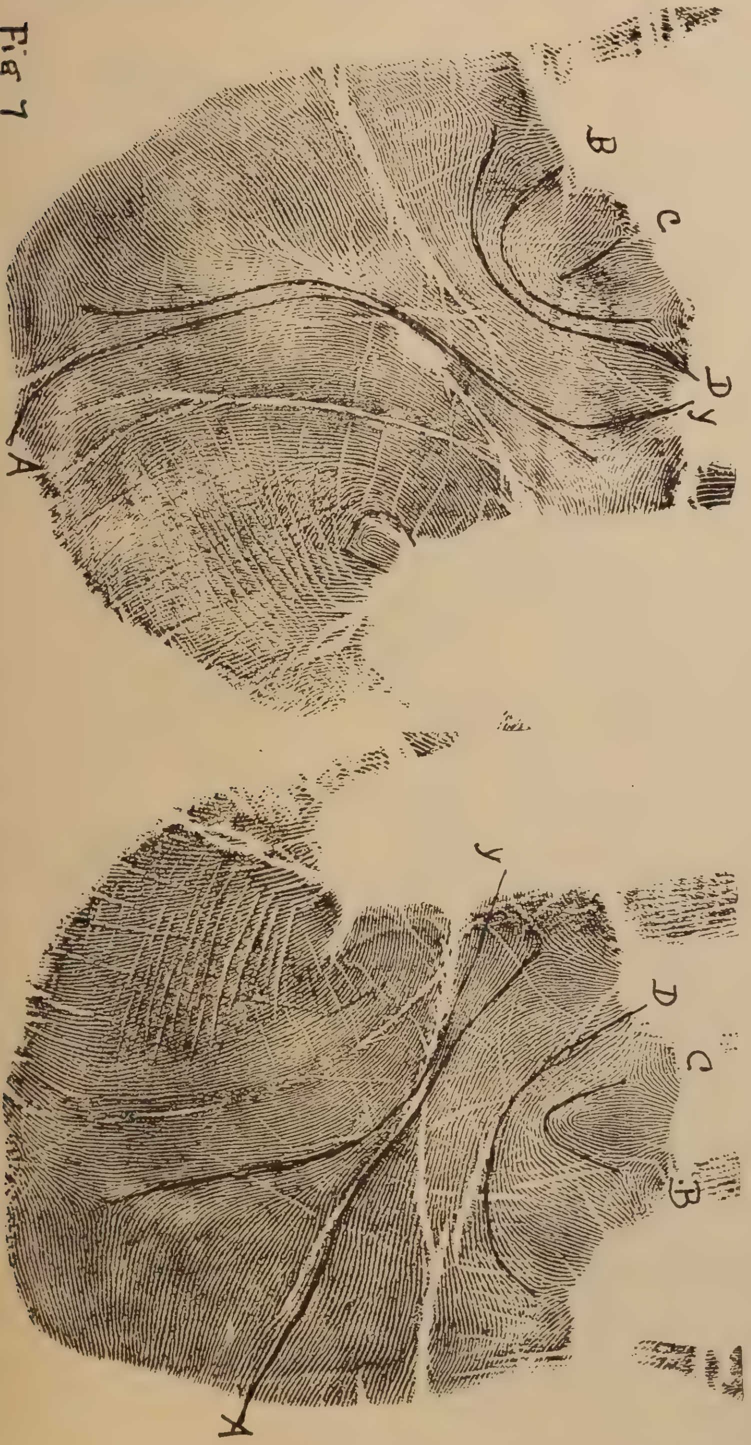

Fig. 7—Hawaiian girl. (See Appendix, S. 6, Honolulu Industrial School.)

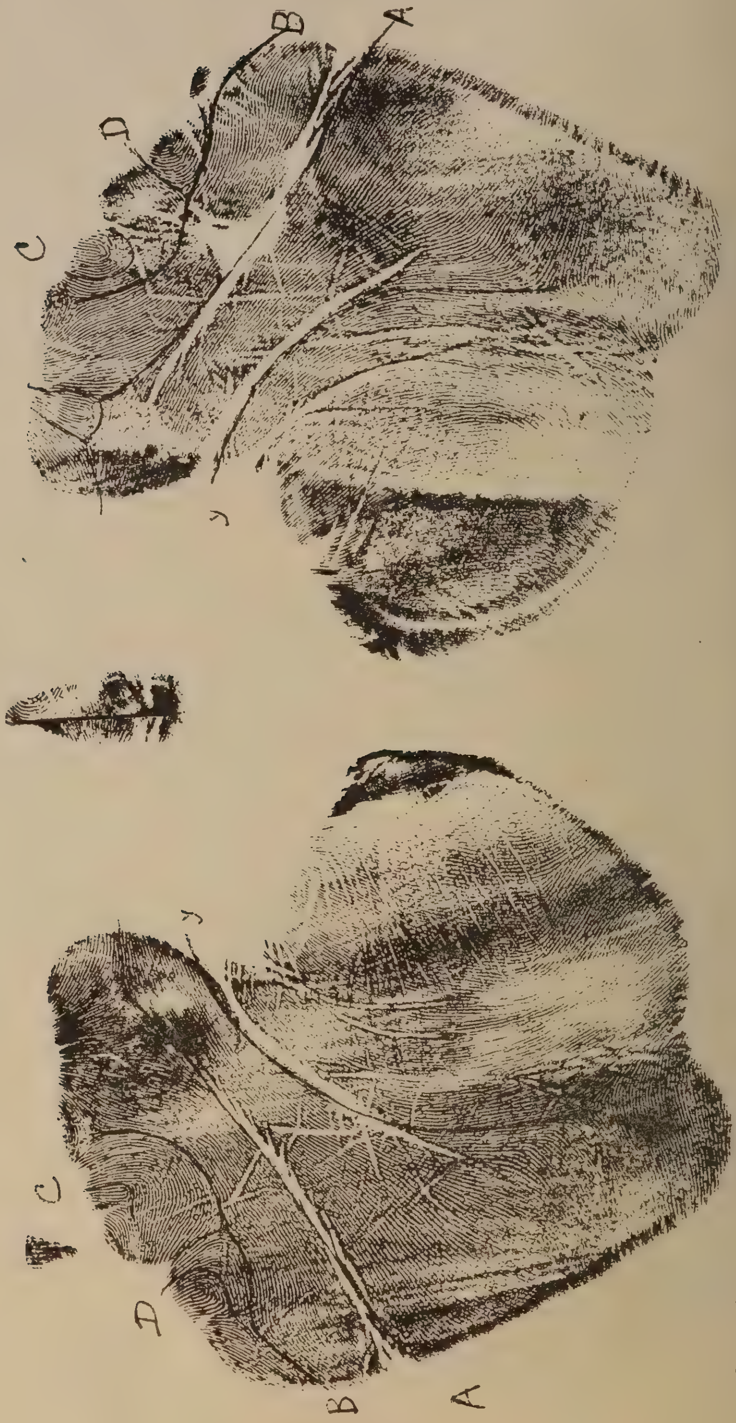

FIG. 8—Amer. Negro—Left palm—formula, 7.9.5.5. Right palm—formula, 7.9.5.5.

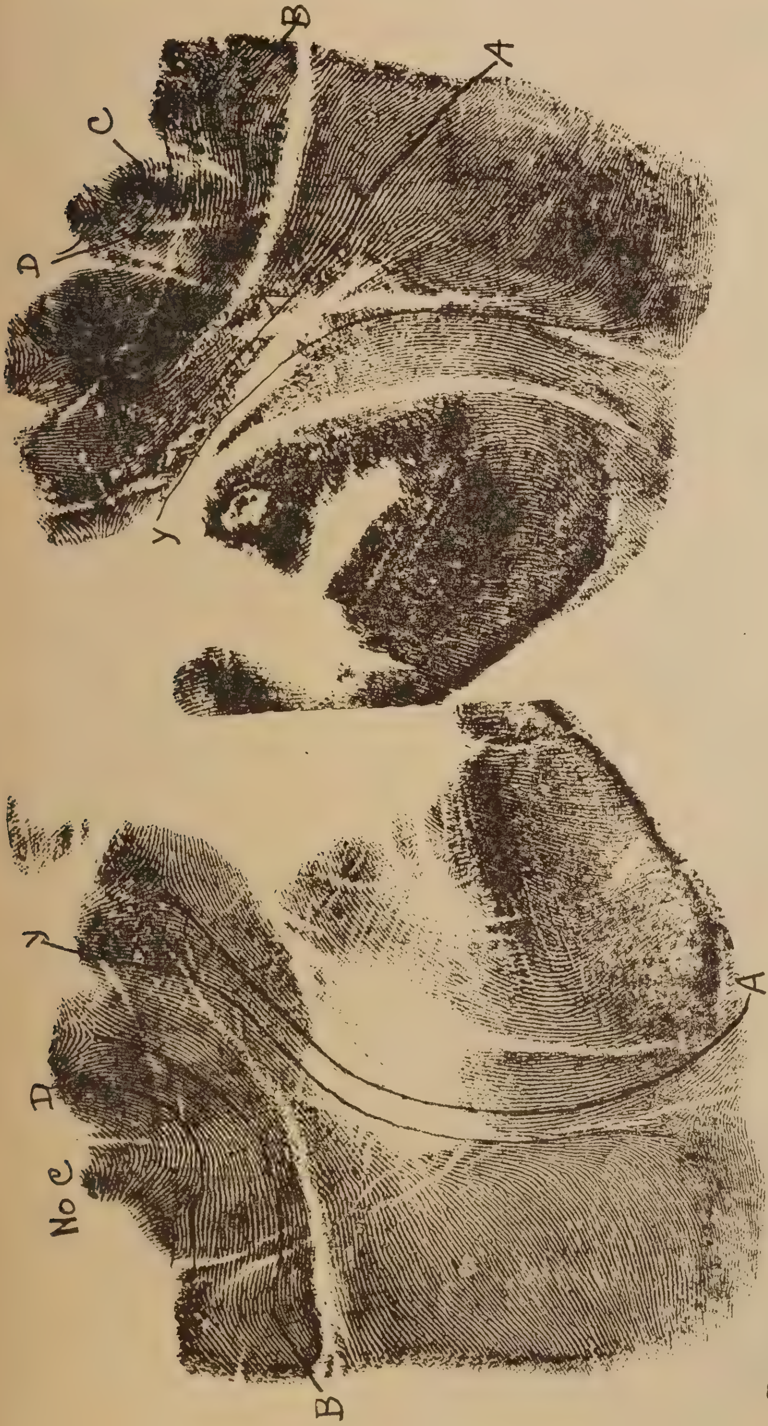

Fig. 9

Fig. 9—South-Amer. Indian (Kechwa)—(See Appendix, S. No. 24.)

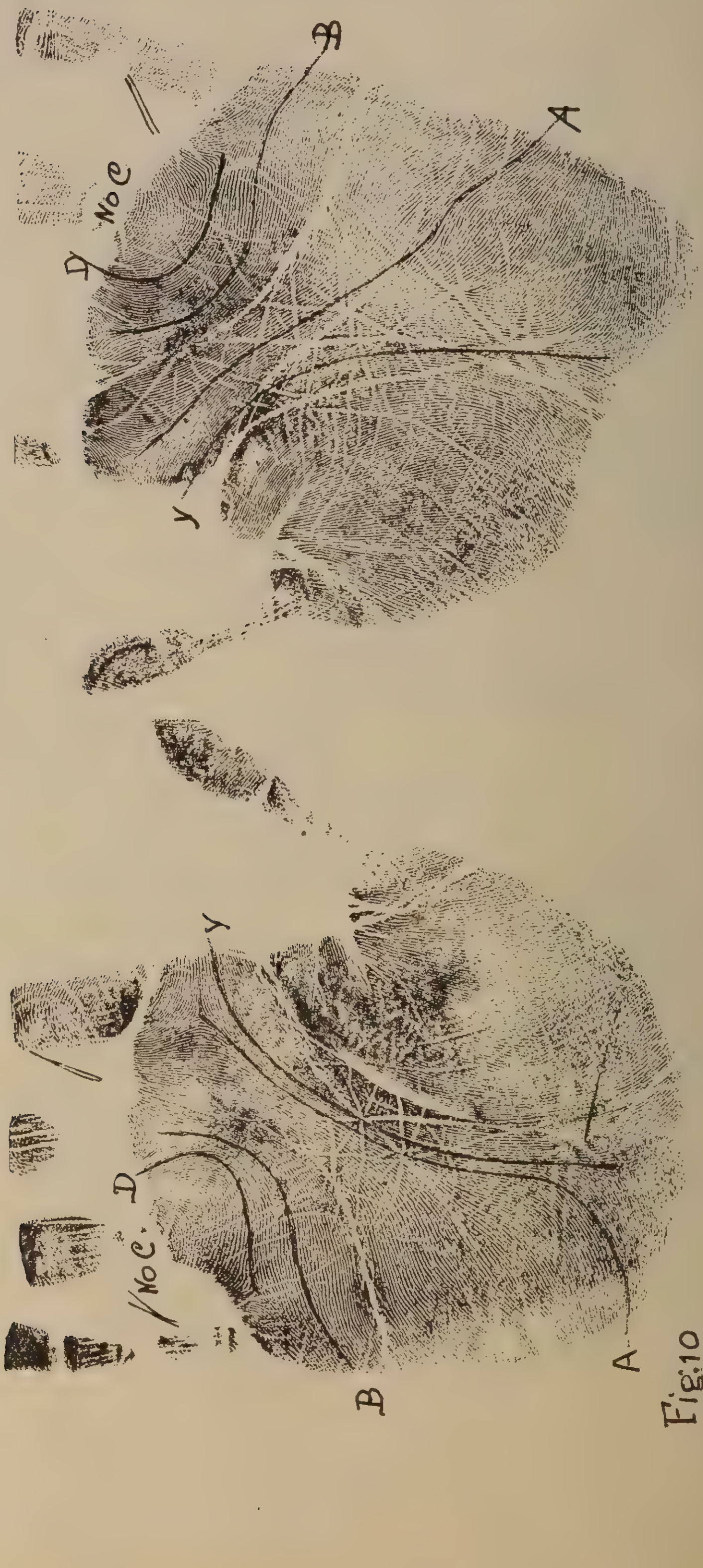

FIG. 10—S. Amer. Indian (Aymara)—(See Appendix, S. No. 27.)

respectively of the left hands, and in 4% and 0% of the right: They thus approach the Whites in this regard, while the Koreans still more resemble the Whites by having a trifle over 12% of the left hands and none of the rights with the extremely low position of Line A. Consulting Wilder's data on the Negroes, I find no left-hand formula that shows a position below 3, nor any right-hand formula. Wilder states that 7.5.5.5. is the typical Negro formula, occurring in a majority of right and left hands. (See Fig. 8.) Now, a very low ending of Line A means that it assumes an approximately longitudinal direction, while the ending 5 would mean an approximately transverse direction. It would seem therefore that the left hand of the races less advanced in culture retained in the papillary ridges a suggestion of the primitive transverse and longitudinal folding of the palm long after such actual folding had in effect disappeared. Nor is it singular that the left hand, which is morphologically the more conservative, should be the one to retain this age-old story. The Negroes show the transverse type of papillary line direction, the Hawaiians and American Indians the longitudinal type. Have these facts also to do with racial relationships and affinities? In all probability they have. (See Figs. 7, 8, 9, 10, 11, 12, 13.)

It is very interesting to compare the different races in regard to the course of Line D. Starting at the tri-radial center at the base of the little finger, it wends its way toward the opposite side of the palm, finding the margin at positions 11, 10, 9, 8 or 7. Very rarely does it end in 13, and practically never below 7. It attains its highest positions of course in the right hand, that is, with right-handed people. In the White race, right hand, it attains positions 11. or 10. in approximately 57% of the cases studied; in the Japanese right hands, in 41%; in the Koreans, in 37.5%; in the Hawaiians, in 37.9%; in the Filipinos, in 30.2%; in the Aymaras, in 30.3%; in the Kechwas, in 20%. With the Negroes, Wilder's statistics show 8 out of 37 right hands where D has this position, namely, in 21.6%. In the left-handed individuals I have studied, Line D is symmetrically placed in the two hands in 50.9% of the cases, and is distinctly higher in the left hand than in the right in 20.7% of the cases. Evidently the height which Line D attains has some functional meaning.

The general height of the formulae attained by each race may be conveniently set forth by indicating the most common formulae found in each hand in the order of their frequency.

Table I.

Whites

100 Left hands		*100 Right hands*	
$11.\left\{\begin{matrix}9.\\8.7.5.\ (4)\\0.\end{matrix}\right.$	25%	11.9.7.5. (4)	31%
$9.\left\{\begin{matrix}9.\\8.5.4.\\0.\quad 5.\end{matrix}\right.$ 7.	24%	$11.\left\{\begin{matrix}8.\\0.7.5.\ (4)\end{matrix}\right.$	12%
		$9.\left\{\begin{matrix}7.5.4\\9.\end{matrix}\right.$	12%

Japanese

100 Left hands		*100 Right hands*	
7.5.5.3. (4) (2)	34%	11.9.7.5. (4) (3)	29%
9.7.5.4. (3) (2) (5)	30%	9.7.5.4. (3)	21%
$11.\left\{\begin{matrix}8.\\9.7.5.\ (4)\end{matrix}\right.$	12%	7.5.5.4. (3)	14%

Koreans

32 Left hands		*32 Right hands*	
9.7.5.5. (4) (3)	28%	9.7.5.3. (4) (5)	28%
7.5.5.4. (3)	28%	$11.\left\{\begin{matrix}0.\\9.7.4.\ (5)\end{matrix}\right.$	25%
		7.5.5.4. (3)	25%

Hawaiians

28 Left hands		*27 Right hands*	
$7.5.\left\{\begin{matrix}4.\\5.2.\end{matrix}\right.$	36%	11.9.7.5. (4)	36%
$9.\left\{\begin{matrix}8.\\7.5.2.\ (3)\end{matrix}\right.$	25%	7.5.5.4. (3)	26%
		$9.\left\{\begin{matrix}0.\\9.5.5.\ (4)\end{matrix}\right.$	14%

Filipinos

43 Left hands		*43 Right hands*	
$7.5.\left\{\begin{matrix}4.\\5.3.\ (4)\ (2)\ (1)\end{matrix}\right.$	41%	$7.5.\left\{\begin{matrix}5.\\4.3.\ (5)\end{matrix}\right.$	34%
9.7.5.3. (4)	23%	$9.7.\left\{\begin{matrix}4.\\5.3.\ (4)\end{matrix}\right.$	25%
		$11.\left\{\begin{matrix}8.\\9.7.5.\ (4)\\0.\end{matrix}\right.$	23%

South American Indians
(Aymara)

32 Left hands		*33 Right hands*	
7.5.5.2. (3) (4) (1)	36%	$9\left\{\begin{matrix}.0.5.4.\ (5)\ (3)\\7.\end{matrix}\right.$	38%
9.0.5.2. (3) (4)	42%	$11.\left\{\begin{matrix}9.7.5.\ (3)\ (4)\\0.\end{matrix}\right.$	21%

South American Indians
(Kechwa)

29 Left hands		*30 Right hands*	
9.0.5.1. (2) (3) (4)	33%	$9.\left\{\begin{matrix}0.\\7.5.\\8.\end{matrix}\right.\left\{\begin{matrix}5.\\4.\ (3)\end{matrix}\right.$	38%
8.6.5.2. (3)	20%		
7.5.5.2. (3)	16%	8.6.5.4. (3)	16%

TABLE II. RACIAL DIFFERENCES IN TERMINATION OF MAIN LINES. (See data in Appendix).

No. of Indiv.	Line D	*Left Hands*						*Right Hands*						
		11	10	9	8	7	0	11	10	9	8	7		0
		%	%	%	%	%	%	%	%	%	%	%	%	%
32	Korean	13	3	28	6	44	9	31	6	28		32		3
100	Japanese	19		42	2	37		41	3	34	3	19		
43	Filipinos	17	5	30		49		25	5	35		35		
25	Hawaiian	16	8	40	4	32		40		24	8	28		
100	White	36	6	38	2	18		54	3	26	2	15		
25	Wh.-Haw	12	8	48		32		28	12	40		20		
22	Ch.-Haw	26	1	36	9	27		50		23		27		
60	S. Amer. Ind	5	5	43	17	30		14	11	48	12	15		
22	Maya Ind		18	37	9	37		30	20	35	5	10		
‡	Negro	2	2	27	8	71		19	3	13	8	57		

	Line C	10	9	8	7	6	5	4	0	11	10	9	8	7	6	5	4	0
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
32	Korean		10	3	31	3	47		6	3	6	16		32		31		12
100	Japanese		18	7	36	2	37			1	3	39	6	28	4	17	1	1
43	Filipino		11	2	43		40	2	2			30	5	28	2	33		2
25	Hawaiian		12	8	48	4	28					47	1	8	8	28		8
100	White	1	29	24	23	1	14		8	1	2	47	13	12	3	12		7
25	Wh. Haw		28	8	28	4	28		4	4	4	40	8	24		16		4
22	Ch. Haw		18	9	41	9	23					55	4	18		23		
60	S. Amer. Ind		8	2	18	15	29		28		2	14	2	19	7	15		36
22	Maya Ind		23	23	9	9	36		†			50	15	20	5	10		†
‡	Negro		6	8	27		59					38	8	8	8	38		

	Line B	9	8	7	6	5	4	9	8	7	6	5	4
		%	%	%	%	%	%	%	%	%	%	%	%
32	Korean			10	6	81	3	3	3	28	7	56	3
100	Japanese			19		81		1	3	38	2	56	
43	Filipino			21	3	73	3			27	4	60	9
25	Hawaiian			16	12	67	5			40		60	
100	White			35	6	58		1	2	52	3	42	
25	Wh. Haw			12	8	76	4	4	4	16	12	64	
22	Ch. Haw			26	1	68	5			50		50	
60	S. Amer. Ind			7	3	88	2		2	15	8	75	
22	Maya Ind				18	82				30	20	50	
‡	Negro			3	2	95				20	10	70	

	Line A	5	4	3	2	1	11	5	4	3	2	1
		%	%	%	%	%	%	%	%	%	%	%
32	Korean	13	47	28	12			10	59	31		
100	Japanese	19	30	30	21			32	46	20	2	
43	Filipino	6	28	47	7	2		21	48	30	1	
25	Hawaiian	4	16	4	76			36	56	8	1	
100	White	30	37	21	12			48	31	17	4	
25	Wh. Haw	12	24	24	36	4		36	40	12	12	
22	Ch. Haw	15	26	23	32	5		27	55	9	9	

I have listed, above, the races and ethnic groups represented in my own collection of hand-prints, in the diminishing order of height of formulae. The Negroes, with the prevailing formula, 7.5.5.5, (Wilder) would belong at the end of the list.

Comparisons in regard to Line C yield other points of interest: In the S. American Indians, (Aymaras and Kechwas), Line C is absent altogether in 32% of the 120 hands studied. It is abortive, (Pos. 8) in 2%. In the White hands, Line C is missing in 7.5% of the 200 hands studied. It assumes Pos. 8 in 18.5%. In all the other races, either condition is comparatively rare, both together never totaling more than 8%, with however one notable exception, viz., the Maya Indians. In Wilder's study of 22 Mayas, he reports 23% of the left hands and 15% of the right hands as showing no C. at all or a very short abortive line—the former condition being more frequent. Maya, Aymara and Kechwa Indians are thus seen to be brothers in the possession of this characteristic common trait, to wit, the frequent absence or abortion of Line C. They are alike, also, as we have seen, in the many very low terminations of Line A in the left hand in contrast to its much higher termination in the right,—which trait they share with the Hawaiians. The Aymaras and Kechwas do not intermarry. They are traditional enemies, speaking a different tongue, and the hand-prints were taken by me in districts separated by more than 250 miles of desert altitudes: The Aymaras, at Tiahuanaco, near Lake Titicaca; the Kechwas, at Cuzco.

All of the above facts in regard to position of main lines and height of formulae for each ethnic group studied appear, in different form, in Table II., where the percentage of times that each line, D, C, B, A, terminates in a given place on the margin of the palm of right and of left hands is listed separately for each group.*

Wilder also made a point of comparing the races in regard to the variety of formulae displayed. He concluded that the left hand is more variable than the right. I have not found this always to be the case. If comparisons in the matter of variety of formulae are to be made, the number of individuals in the different groups compared must be brought to a like figure. Neither too few nor yet too many should be included. If too many, opportunity is given for the intrusion of odd variants who serve to augment the number of different formulae out of all proportion to their representation. It is indeed quite conceivable that if one searched far enough among the members of each race, he could bring the number of different formulae up to the same figure for all, since it is con-

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*For data from which Tables I. and II. were derived, see Appendix.

Fig. 11.

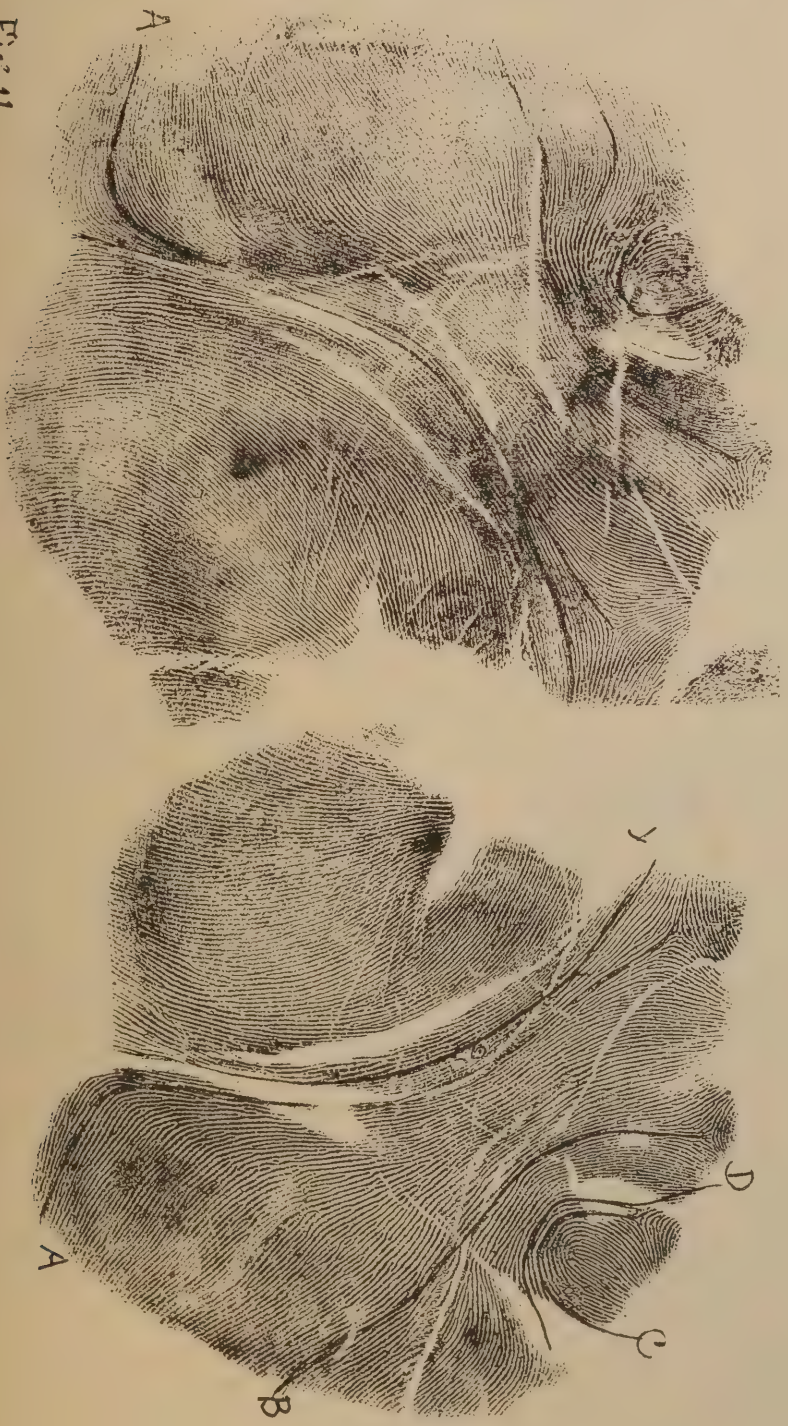

Fig. 11—Filipino (Visayan)—(See Appendix, S. No. 33.)

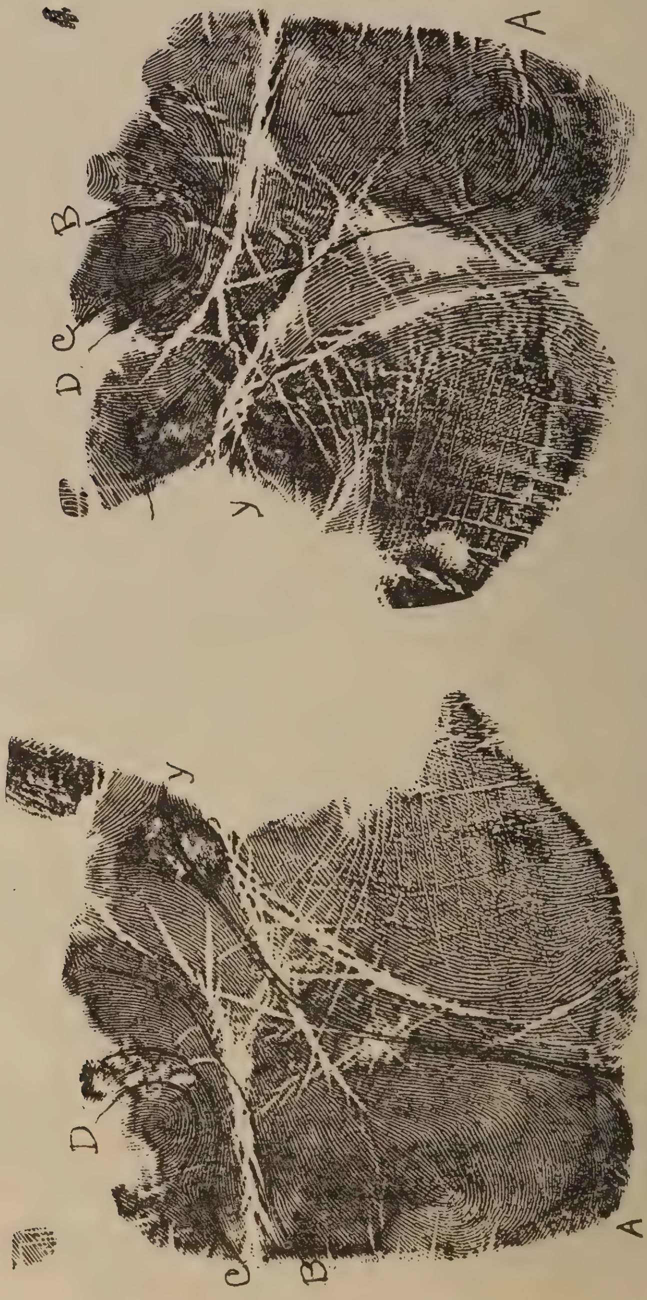

FIG. 12—Japanese. Left palm-formula, 7.5.5.3. Right palm-formula, 11.11.9.4.

ceded by biologists that the human race is of one species. The comparison loses its merit unless we take a limited number of subjects of random selection, though not too limited to show any considerable tendency to variation that may exist. To test the matter empirically, I found that the 100 Japanese whose palm prints I had made, and listed in a chance order before even determining their formulae, showed 77% of the varieties of formula displayed by 100 American Whites listed in the same random manner. When the first 50 of each list were compared, the Japanese showed 70% of the varieties shown by the Whites. Again when the first 28 in each list were compared, the ratio was 72% and in the same direction. Therefore, for purposes of expediency as well as of accuracy, it seemed that groups of about 28 individuals would yield reliable, if approximate, data on the matter of variability. To confirm the principle, I compared 42 Filipinos with 42 Negroes to find that the former showed twice as many varieties as the latter, while the first 28 individuals in each random list displayed practically the same ratio, viz., 2.2.

TABLE III. VARIETIES IN FORMULAE

	Right only	Left only	Common to both	Total in Right	Total in Left	Varieties Total
28 individuals—White	9	13	10	19	23	32
28 " Japanese	7	6	10	17	16	23
28 " Koreans	9	11	6	15	17	26
28 " Filipinos	7	14	6	13	20	27
28 " Hawaiians	14	10	2	12	14	26
28 " Aymaras	10	10	7	17	17	27
28 " Kechwas	10	11	4	14	15	25
20 " Mayas	6	10	4	10	14	20
28 " Negroes	3	2	7	10	9	12

The White race is seen to be the most variable of all; the Negroes the least. The other races are intermediate between these pronounced extremes, being about on a parity with each other. The Maya varieties would probably be brought up to the same level by the addition of 8 more individuals to the 20 that were the subjects of Dr. Wilder's study. The rank of the races in regard to *total varieties* exhibited by the *right hand* is about the same as their rank in the matter of height of formulae.

In regard to the retention or elimination of patterns in the palm, I shall speak only of the Thenar and Hypothenar areas, since they appear more significant in the comparison of races. The only racial groups displaying more thenar than hypothenar patterns are the Negro and Maya, (as stated by Wilder), and the Aymara and Kechwa, the left thenar much more often retaining the pattern than the right. In all other

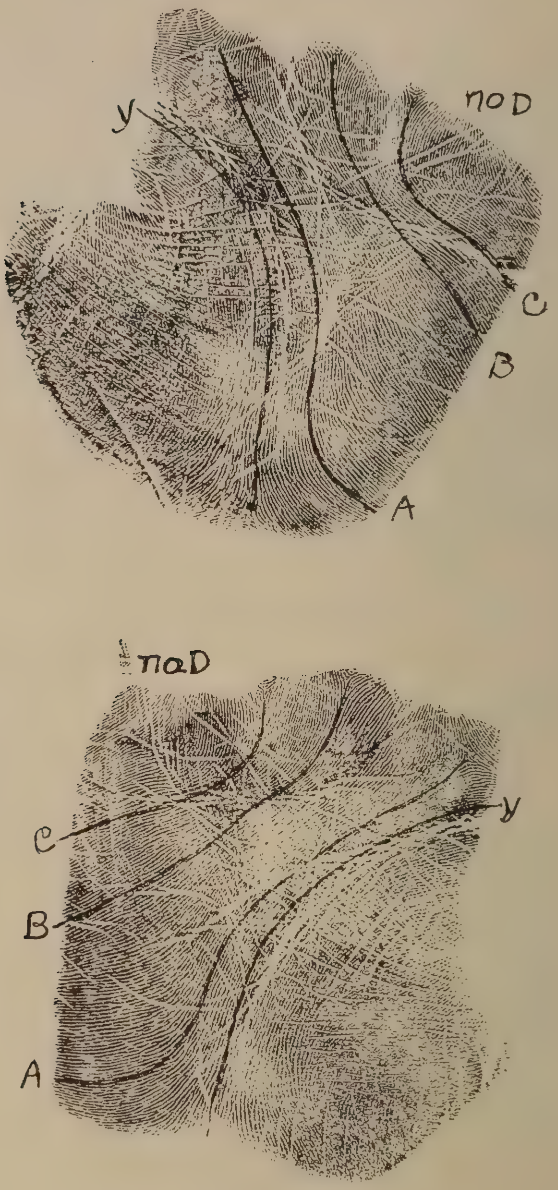

FIG. 13—Korean. (See Appendix, S. No. 17.)
Note absence of Line D.—a peculiarity of the Koreans.

races, the hypothenar patterns are considerably in excess of the thenar, which is not surprising in view of the fact that the ulnar is the more conservative side of the hand. Likewise we should expect the left ulnar to carry more patterns than the right, which is the case with all but the Japanese and White. These two races show more hypothenar patterns in the right hand than any other race. This could hardly be thought an atavistic trait in the two races having the fewest thenar patterns and the highest formulae. There would seem to be some functional reason favoring the retention of the right hypothenar pattern. When the fingers are closed down on the palm as in handling a tool, the little finger is brought into contact with the very spot where hypothenar patterns are prone to develop, or else the tool is pressed against this spot, which therefore develops a guiding touch function similar to that which has kept the patterns on the finger-tips. The radial or thumb side of the hand has pre-eminently the muscular function. The retention of the thenar pattern is therefore atavistic.

On the basis of the relative number of thenar and hypothenar patterns, I have given the races an approximate rank order. The number of individuals in some of the groups is too few however, for a feeling of certainty: It is seen that, on the whole, as thenar patterns increase in number, hypothenar patterns diminish in number.

TABLE IV.

Patterns %	Thenar		Hypothenar		Th.	Hyp.
	Left	Right	Left	Right	Total	Total
100 Whites	8	4	36	42	6	39
100 Japanese	12	0	19	26	6	22.5
32 Koreans	15.6	3.1	21.9	15.6	9.3	18.7
43 Filipinos	14	2.3	14	7	8.1	11
29 Hawaiians	17.	10.3	55.2	20	13.6	37.6
100 Negroes	20	10	16	17	15	16.5
32 Kechwas	31	9.3	9.3	18.6	20.1	13.9
33 Aymaras	18	12	6	9	15	7.5
22 Mayas	54.5	50	4.5	4.5	52	4.5

Effect of Racial Mixture on the Papillary Lines

On *a priori* grounds one would suppose that racial mixtures would show a greater variety of formulae than the purer-blooded groups, and that the characteristics of the parent races in regard to height of formulae, symmetry or asymmetry, patterns, etc., would appear in due proportion in the fused product.

While taking hand-prints in the Hawaiian Islands, though primarily searching for pure types, I was enabled to add to my collection the prints

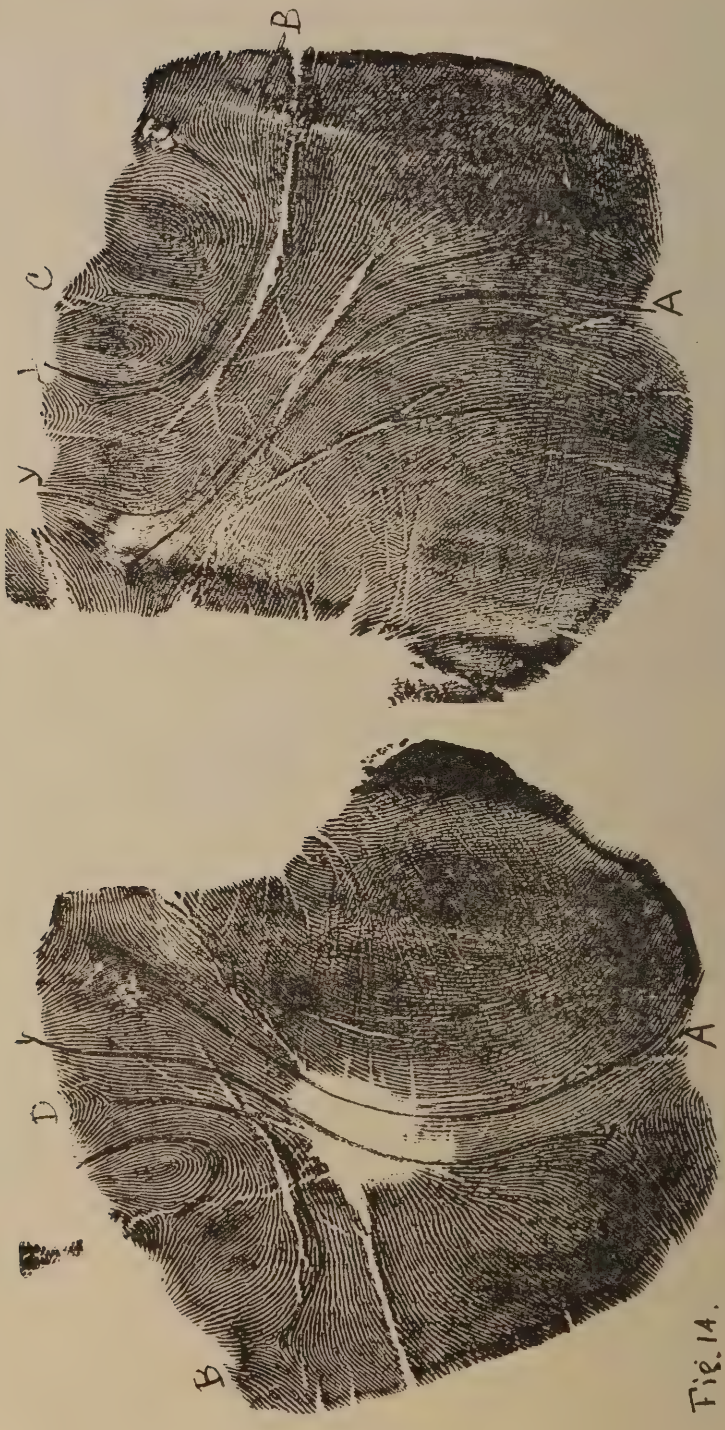

Fig. 14.

White-Hawaiian. (See Appendix, S. No. 2, Honolulu Industrial School.)

of the hands of 75 Part-Hawaiians of whom 25 were quite surely of White-Hawaiian ancestry and 22 of Chinese-Hawaiian ancestry. One would expect the White-Hawaiian racial mixture to display higher formulae than do the pure Hawaiians. On the contrary, a larger percentage of low positions for the main lines is found in the racial mixture than in the pure-blooded group. Only in Line A in the left hand is the extremely low position found in the Pure-Hawaiians raised in 36% of the cases. Line C is also raised somewhat in 20% of the cases, in both hands. The Hawaiian influence is much stronger than the White. Indeed, more than this, it is lowered in its status. All this can be seen by studying the figures in Table II. (See Fig. 14.)

With the Chinese-Hawaiians, on the other hand, the result of racial mixture has been to raise the formulae to a remarkable degree above the Hawaiian, the percentage of high positions rivaling that of the Japanese, in some cases exceeding them. While I have no Chinese hand-prints with which to make comparison, it would seem that the Mongolian influence comes out very strongly in the Chinese-Hawaiian mixture, perhaps being improved thereby. Does this point to a common Asiatic ancestry in some remote time, or do the papillary-line phenomena of these mixed Hawaiian groups indicate that some races mix to advantage while others do not? The Chinese-Hawaiians have a high reputation in the Islands, in the schools and in the ranks of industry and the professions, for ability and character. They are said to combine the genial and tractable disposition of the Hawaiians with the stability and intelligence of the Chinese. (See Fig. 15.)

In regard to variety of formulae displayed by these racial mixtures, our *a priori* expectations are somewhat gratified. The White-Hawaiians show a slightly greater variety than do the Whites or Hawaiians alone. The Chinese-Hawaiians, however, show fewer varieties than do the Pure-Hawaiians, tending rather toward the homogeneity that is shown by the Japanese. It seems that racial mixture does not always add to the variety of formulae, but that the quality of variability or the lack of it in any one of the races mixed affects the degree of variability of the resultant. Of course in the absence of any data on the Chinese, even the premises here are uncertain, and the conclusion merely hypothetical. If the principle should be confirmed by subsequent studies of racial mixtures, it would strengthen the assumption that the greater variability of the Europeans and their American descendants is due not to the larger number of ethnological strains in their composition, but rather to the inherent quality of variability in one or more of the component strains.

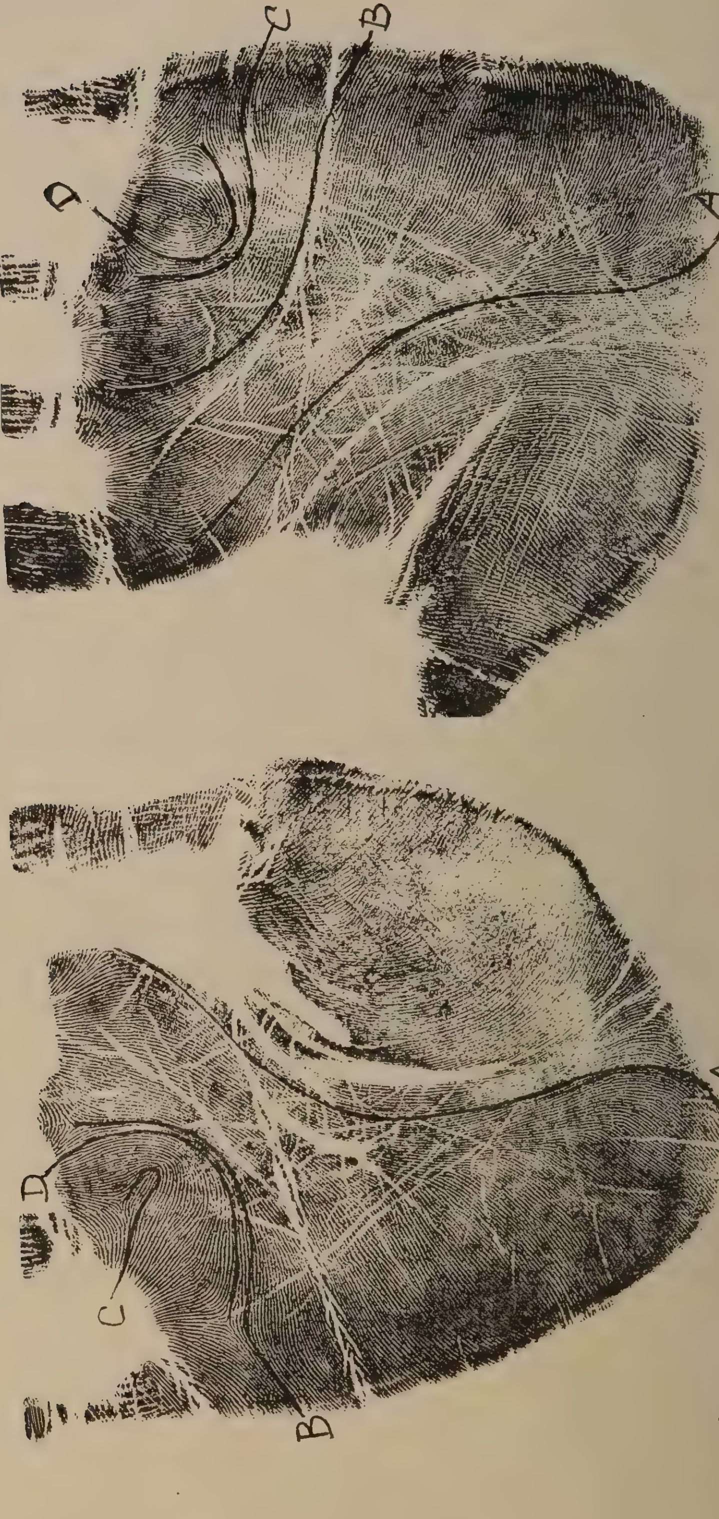

Fig. 15

Chinese-Hawaiian—(See Appendix, S. No. 14.)

TABLE V. VARIABILITY OF PURE AND MIXED HAWAIIAN

No. of dif. Form. in	L, alone,	R. alone,	Both hands	Total
25 Whites	15	8	4	27
25 Hawaiians	14	9	2	25
25 White-Hawaiians	10	9	9	28
22 Hawaiians	13	10	1	24
22 Chinese-Hawaiians	12	3	6	21
22 Japanese	5	6	6	17

Schlaginhaufen's study of the natives of Farther India and Ceylon and Loth's study of the Russian Poles may, as far as the data make possible, be brought into line with the present study. Loth finds the formula, 11.9.7.5., in 27.2% of the hands of Poles, and he also makes mention of an unusual number of positions, 8. for Line C. These are precisely the characteristics of all Whites, only more marked in the Poles than in the American Whites tabulated by Wilder or by me. Schlaginhaufen found among the natives of Farther India and Ceylon a larger percentage of high positions for Lines D. and C. in both right and left hands than had been found among Europeans. 51% of the Indian hands show D. terminating in 11, and 63.4% show C. terminating in 9. My own figures for these positions among American Whites are 45% and 38% respectively. Schlaginhaufen also remarked a greater variety of formulae among the Indians, so that there was no formula possessed by any other race up to that time studied that was not possessed also by the Indians, and some other formulae as well.

We have seen that the papillary lines are significant morphological features since their number and direction are conditioned by more and more developed forms of locomotion, modes of grasping and manipulation, with all the mental adaptations correlated with these. They are intimately related to the evolution of the nervous system, being the repositories of the termini of the afferent neurones concerned with conscious discrimination of touch. The lack of symmetry between right and left palms, peculiar to the human being, is indubitably related to the phenomenon of unidexterity in man. This in its turn has a proved relationship to the unilateral functioning of the cerebral hemispheres especially in the speech centers, those nuclei of abstract thought processes. The papillary lines are unchanging in the life-time of the individual, are a distinctly inherited feature, indicative of race, yet they have an individuality that makes the hand-prints of no two persons exactly alike. Palm-prints afford a rich though, as yet, little-explored field for the anthropologist.

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APPENDIX

PALM FORMULAE OF 100 JAPANESE

Nos.	Formulae								Patterns
	Left				Right				Left Right
	D	C	B	A	D	C	B	A	
1	9	9	5	5	11	9	7	5	Th Hy — Hy
2	9	7	5	2	9	7	5	4	Th —
3	7	5	5	2	7	5	5	2	Hy Hy
4	7	5	5	4	9	7	5	4	
5	7	5	5	4	7	5	5	4	Hy Hy
6	11	7	7	4	9	0	5	3	
7	9	7	5	3	9	7	5	4	Hy Hy
8	7	5	5	4	8	6	5	4	
9	9	9	5	3	7	5	5	4	
10	9	7	5	4	9	9	5	5	
11	11	9	7	5	7	5	5	3	Hy —
12	9	8	5	2	9	7	5	3	Hy Hy
13	9	7	5	4	9	0	5	5	
14	9	7	5	4	11	9	7	4	Hy —
15	9	7	5	5	11	8	7	5	
16	7	5	5	3	10	9	7	4	
17	7	5	5	2	7	5	5	3	Th —
18	9	7	5	3	9	7	5	4	
19	9	7	5	2	9	7	5	4	
20	9	7	5	4	11	9	7	4	
21	11	9	7	5	11	9	7	5	
22	7	5	5	2	9	7	5	5	
23	9	7	5	3	11	9	7	4	
24	8	6	5	2	11	8	7	3	Hy Hy
25	7	5	5	2	8	6	5	3	
26	9	9	5	4	11	9	7	5	— Hy
27	11	9	7	4	11	9	7	5	
28	9	8	5	3	11	9	7	5	
29	9	7	5	3	8	6	5	2	— Hy
30	9	7	5	2	9	9	5	3	— Hy
31	9	7	5	5	11	9	7	5	
32	9	9	5	4	11	9	7	5	
33	7	5	5	3	9	7	5	2	Hy Hy
34	7	5	5	4	9	7	5	4	
35	9	7	5	4	11	7	7	4	Th —
36	9	7	5	4	9	9	5	4	— Hy
37	11	9	7	5	11	9	7	5	
38	11	8	7	4	11	10	8	4	
39	7	5	5	5	7	5	5	5	
40	7	5	5	2	7	5	5	3	
41	7	5	5	2	7	5	5	4	Hy —
42	9	7	5	2	11	9	7	4	— Hy
43	9	7	5	3	10	8	6	3	Hy Hy
44	9	7	5	3	9	9	5	4	Th —
45	11	9	7	5	11	11	9	5	Hy Hy
46	11	8	7	3	11	8	7	4	
47	7	5	5	3	11	8	7	4	Th —
48	8	6	5	4	9	7	5	4	Th —
49	9	7	5	2	9	7	5	3	
50	9	0	5	3	9	7	5	4	
51	11	9	7	4	9	7	5	4	
52	11	7	7	3	11	10	8	4	
53	9	7	5	2	7	5	5	2	
54	11	9	7	4	11	9	7	4	
55	7	5	5	3	7	5	5	4	Hy Hy
56	7	5	5	4	7	5	5	4	Th —
57	7	5	5	3	9	7	5	4	Th —
58	11	9	7	3	11	9	7	3	— Hy
59	9	7	5	4	11	9	7	4	
60	7	5	5	4	9	7	5	5	Th Th
61	9	9	5	4	11	9	7	5	Hy Hy
62	9	7	5	2	11	9	7	3	— Hy
63	9	7	5	5	11	9	7	5	
64	7	5	5	4	9	7	5	4	
65	7	5	5	3	9	7	5	3	— Hy

Nos.	Formulae								Patterns
	Left				Right				Left Right
	D	C	B	A	D	C	B	A	
66	9	7	5	4	9	9	5	5	Hy —
67	7	5	5	2	9	7	5	3	
68	7	5	5	4	9	7	5	4	
69	9	7	5	5	11	9	7	5	Th —
70	11	8	7	4	9	9	5	5	— Hy
71	11	7	7	5	11	9	7	5	
72	11	7	7	5	11	10	8	5	
73	7	5	5	2	8	6	5	4	
74	11	9	7	4	11	9	7	4	
75	9	8	5	4	11	7	7	5	
76	7	5	5	3	7	5	5	3	
77	7	9	7	5	7	9	7	5	— Hy
78	9	7	5	4	11	9	7	4	
79	7	5	5	2	9	7	5	3	— Hy
80	9	0	5	3	11	9	7	5	
81	9	7	5	5	11	9	7	5	
82	11	9	7	3	11	9	7	4	
83	11	7	7	3	11	9	7	5	Hy —
84	7	5	5	3	9	7	5	3	
85	7	5	5	5	9	7	5	5	
86	7	5	5	3	7	5	5	4	
87	7	5	5	4	7	5	5	4	
88	7	5	5	3	9	7	5	3	
89	7	5	5	4	7	5	5	5	
90	7	5	5	3	7	5	5	3	Hy Hy
91	7	5	5	3	9	7	5	4	
92	7	5	5	3	7	5	5	4	
93	9	7	5	2	11	9	7	3	Hy Hy
94	7	5	5	3	10	7	6	4	— Hy
95	9	7	5	4	9	9	5	4	Hy —
96	9	7	5	2	9	7	5	4	
97	7	5	5	5	7	5	5	4	
98	11	9	7	5	11	9	7	4	
99	9	7	5	3	11	9	7	3	Th — — Hy
100	7	5	5	5	11	9	7	5	

PALM FORMULAE OF 32 KOREANS

1	9	7	5	5	9	7	5	3	
2	9	7	5	5	11	9	7	5	
3	11	9	7	3	9	7	5	5	
4	7	5	5	2	9	0	5	3	Hy Hy
5	7	5	5	4	11	9	7	4	Th Th
6	9	7	5	4	10	7	6	4	
7	11	7	7	5	11	9	7	4	
8	7	5	5	3	9	7	5	3	
9	7	5	5	2	9	7	5	3	
10	7	5	5	4	7	5	5	4	
11	9	7	5	3	9	7	5	4	
12	7	5	5	3	7	5	5	4	Hy —
13	10	7	6	4	11	10	8	4	
14	9	7	5	5	11	0	7	5	
15	7	5	5	4	7	5	5	3	Hy —
16	7	5	5	4	7	5	5	3	
17	0	5	4	3	0	5	5	3	
18	9	7	5	3	11	10	7	4	Hy Hy
19	9	9	5	4	11	9	7	4	Th —
20	7	5	5	3	7	5	5	4	
21	7	5	5	4	7	5	5	4	
22	8	6	5	3	9	7	5	3	— Hy
23	10	0	6	4	11	0	7	4	Hy Hy
24	7	5	5	4	11	0	7	4	
25	0	5	5	2	7	5	5	3	
26	0	8	5	4	11	9	7	4	Th Hy — —
27	7	5	5	3	7	5	4	3	
28	9	7	5	4	9	7	5	4	Th —
29	9	8	5	4	9	7	5	4	
30	7	9	5	4	7	11	9	4	Th —
31	11	7	7	4	10	7	6	4	
32	7	5	5	2	7	5	5	4	Hy Hy

PALM FORMULAE OF 43 FILIPINOS

Nos.	Formulae								Patterns	
	Left				Right				Left	Right
	D	C	B	A	D	C	B	A		
Pangasinan										
1	7	5	5	3	7	5	5	3		
Bicol										
2	7	5	5	2	7	5	5	4	—	Hy
3	9	7	7	3	11	7	7	3	—	Hy
Pampangan										
4	9	9	5	3	7	5	5	3		
5	7	7	5	4	7	5	5	4		
6	7	5	5	4	7	5	5	4		
Tagalog										
7	7	5	5	3	9	9	5	4		
8	11	7	7	3	9	7	5	4		
9	9	7	5	3	7	5	5	4		
10	7	5	5	3	9	7	5	4		
11	9	7	5	3	7	5	5	4		
12	7	5	5	3	7	5	5	2	Hy	Hy
13	11	0	7	5	11	9	7	5	—	Hy
14	9	7	5	3	7	5	5	4		
15	6	5	5	4	9	7	5	4		
16	11	7	7	2	11	0	7	5		
17	7	5	4	1	9	7	5	3		
18	11	8	7	2	11	9	7	4		
19	11	7	7	4	11	8	7	5	Th	—
Visayan										
20	11	9	7	2	9	7	5	4		
21	10	9	6	4	10	9	6	4		
22	7	7	5	4	7	5	5	4	—	Hy
Visayan										
23	9	9	5	5	11	9	7	5	Th Hy	Th —
24	9	7	5	4	9	8	5	4		
25	10	7	6	4	11	9	7	5	Hy	Hy
26	7	5	5	4	11	9	7	4		
27	7	5	5	2	9	7	5	3	Th Hy	— —
28	9	7	5	3	8	6	5	4		
29	7	5	5	3	7	5	4	3		
30	7	5	5	2	7	5	4	3	Hy	—
31	7	5	5	3	9	7	5	4		
32	11	7	7	3	11	9	7	4		
33	7	5	5	3	9	7	5	3		
34	7	5	5	4	11	9	7	5		
35	7	5	5	4	7	5	5	5	Th	—
36	9	7	5	3	11	9	7	5	Th	—
37	9	7	5	2	9	7	5	3		
38	9	7	5	3	9	9	5	4	Th	—
Ilocano										
39	7	4	4	2	7	5	4	3		
40	9	7	5	3	9	7	5	3		
41	7	7	5	3	9	9	5	4		
42	9	7	5	5	10	8	6	5		
43	7	5	4	3	7	5	5	4		

PALM FORMULAE OF 60 HAWAIIANS—(THOUGHT TO BE OF PURE BLOOD)

1	7	9	5	2	8	6	5	4	Hy	—
2	8	6	5	2	9	7	5	4		
3	7	5	5	2	7	5	5	3	Hy	Hy
4	11	7	7	3	11	0	7	5		
5	7	5	5	2	8	6	5	3	Hy	—
6	7	5	5	4	7	5	5	4	Hy	—
7	9	7	5	2	11	9	7	4		
8	9	8	5	2	9	9	5	5	Th Hy	Th Hy
9	7	5	5	2	7	5	5	4	Hy	—
10	9	7	5	3	11	9	7	5	Hy	—
11	9	7	5	2	11	9	7	5	Th	—
12	7	5	4	2	7	5	5	4		
13	9	7	5	2	7	5	5	4	Hy	—
14	9	7	6	2	11	9	7	5	Hy	—
15	7	5	5	2	9	9	5	5		
16	10	7	6	2	11	9	7	5		

Nos.	Formulae								Patterns
	Left				Right				Left Right
	D	C	B	A	D	C	B	A	
17	9	7	5	2	11	9	7	4	
18	7	5	4	2	—	—	—	—	Hy —
19	7	5	5	2	—	—	—	—	Hy Hy
20	—	—	—	—	11	9	7	4	Th Hy Th Hy
21	9	7	5	2	11	9	7	4	Hy Hy
22	11	7	7	2	9	7	5	5	Hy Hy
23	7	5	4	2	9	9	5	4	Th —
24	10	9	6	2	7	5	5	4	
25	11	7	7	4	11	9	7	5	Hy —
26	9	8	5	4	7	5	5	4	
27	9	7	5	2	9	0	5	4	Hy —
28	11	9	7	4	11	9	7	4	— Th
29	7	5	5	2	9	7	5	4	Th —

From the Honolulu Industrial School for Girls

Nos.	Left D	C	B	A	Right D	C	B	A	Patterns Left Right
1	7	5	5	3	10	6	5	4	
2	7	5	5	2	8	6	5	3	
3	7	5	5	2	8	6	5	4	
4	7	5	5	2	9	7	5	4	Th Hy Th Hy
5	7	5	5	2	9	7	5	2	Hy Hy
6	11	8	7	2	11	10	8	4	
7	7	5	5	2	9	7	5	4	
15	0	5	4	1	7	5	5	3	Th
16	9	7	5	3	10	7	6	4	
17	9	7	5	3	9	7	5	5	Hy —
18	7	5	5	2	9	7	5	3	
19	9	7	5	3	7	7	5	4	
20	11	8	7	3	11	9	7	5	Th Th
21	9	0	5	3	11	0	7	4	
22	7	5	5	2	9	7	5	4	— Th
23	9	0	5	1	9	7	5	4	
8	7	5	5	2	8	6	5	4	
9	7	7	5	1	10	7	6	5	
10	7	7	5	4	7	5	5	5	Th —
11	7	5	5	3	7	5	5	2	
12	11	7	7	3	11	9	7	5	Th Th
13	11	9	7	5	10	7	6	5	Hy Hy
14	11	9	7	3	11	9	7	4	— Hy
24	7	5	5	3	9	7	5	4	
25	9	7	5	2	11	9	7	4	
26	9	8	5	3	10	9	6	4	— Hy
27	9	9	5	5	11	9	7	5	Th Hy Th Hy
28	7	5	5	2	8	6	5	4	
29	9	0	5	4	11	10	8	5	
30	9	9	5	3	11	7	7	3	
31	7	5	4	3	9	7	5	3	

PALM FORMULAE OF 25 PERSONS OF MIXED WHITE AND HAWAIIAN ANCESTRY

Nos.	Left D	C	B	A	Right D	C	B	A	Patterns Left Right
1	7	5	5	2	7	5	5	4	
2	7	5	5	4	9	7	5	5	
3	7	4	4	2	9	7	5	2	
4	7	5	5	2	9	7	5	2	— Th
5	9	8	5	5	7	9	5	5	Hy Hy
6	7	0	5	4	11	9	7	5	Hy Hy
7	11	7	7	2	9	9	5	2	Th — Th Hy
8	9	7	5	5	11	7	7	5	
9	7	5	5	2	9	7	5	5	
10	9	8	5	3	9	?	5	4	
11	9	9	5	4	9	8	5	4	Th —
12	7	5	5	2	7	5	5	3	Hy —
13	7	5	5	3	7	5	5	4	
14	9	8	5	3	11	9	7	4	
15	9	7	5	3	9	7	5	4	Hy —
16	9	7	5	3	10	9	6	3	Hy Hy

Nos.	Formulae								Patterns	
	Left				Right				Left	Right
	D	C	B	A	D	C	B	A		
17	9	7	5	2	9	?	5	4		
18	9	7	5	4	10	9	6	5		
19	10	7	6	2	11	10	8	5		
20	9	9	5	2	9	9	5	4	Hy	Hy
21	9	7	5	5	9	9	5	5		
22	9	9	5	3	9	9	5	3	Th Hy	Th —
23	10	9	6	3	11	9	7	5		
24	7	5	5	2	7	5	5	4		
25	9	7	5	3	11	8	7	5	Hy	—

PALM FORMULAE OF 22 PERSONS OF MIXED WHITE AND HAWAIIAN ANCESTRY

From the Honolulu Industrial School for Girls

1	7	5	5	2	8	6	5	3	Hy	—
2	10	9	6	2	9	8	5	2		
3	9	0	5	1	10	8	6	4	Th	Th
4	10	9	6	2	9	7	5	3		
5	11	9	7	5	11	9	7	5	Hy	—
6	7	5	5	2	8	6	5	3	Hy	Hy
7	7	5	5	2	10	9	6	5		
8	9	9	5	4	11	9	5	4	—	Hy
9	10	7	6	2	11	9	7	4		
10	9	8	5	2	10	9	6	4	Hy	—
11	7	5	5	2	9	7	5	3		
12	11	8	7	5	10	8	6	5		
13	7	5	5	2	9	7	5	4	Th —	— Hy
14	7	5	5	1	7	5	5	4		
15	7	5	5	2	7	5	5	3		
16	9	7	5	5	9	7	5	5		
17	11	9	7	3	11	11	9	4		
18	7	5	5	1	9	7	5	2	—	Hy
19	9	7	5	3	9	7	5	4	—	Hy
20	7	5	5	2	9	7	5	4	Th Hy	— —
21	11	9	7	4	11	8	7	4		
22	7	7	5	2	9	9	5	2	Hy	Hy

PALM FORMULA OF 22 PERSONS OF MIXED CHINESE AND HAWAIIAN ANCESTRY

1	9	8	5	2	11	9	7	4		
2	7	7	5	3	10	9	6	5	—	Hy
3	11	9	7	2	11	9	7	5	Hy	Hy
4	11	9	7	5	7	9	5	5		
5	9	7	5	3	11	9	7	5		
6	8	6	5	2	9	7	5	4		
7	9	7	5	3	11	9	7	4	Th	—
8	7	5	5	3	7	5	5	4		
9	8	6	5	2	9	7	5	3		
10	11	7	7	4	11	9	7	5		
11	7	5	4	2	11	9	7	3		
12	7	5	5	3	7	5	5	4		
13	7	5	5	4	7	5	5	4	Hy	—
14	9	7	5	2	7	5	5	2	—	Hy
15	9	7	5	4	11	9	7	4		
16	11	9	7	4	11	9	7	5		
17	11	7	7	5	11	9	7	4		
18	7	5	5	2	9	7	5	4		
19	11	8	7	5	9	7	5	4	Th	—
20	9	9	5	4	11	9	7	5		
21	9	7	5	4	9	8	5	4	—	Th
22	9	7	5	1	7	5	5	2		

PALM FORMULAE OF 31 KECHWA INDIANS

Nos.	Formulae								Patterns	
	Left				Right				Left Right	
	D	C	B	A	D	C	B	A		
1	8	6	5	2	8	6	5	4		
2	8	6	5	2	7	5	5	4		
3	10	0	6	2	9	7	5	4		
4	7	5	5	2	7	5	5	4	Th —	
5	8	6	5	2	9	7	5	3		
6	8	6	5	2	8	6	5	3		Hy Hy
7	7	5	4	2	9	8	5	4		
8	7	5	5	3	10	9	7	5	Th Th	
9	7	0	5	3	9	0	5	4	Th —	— Hy
10	9	7	5	3	9	0	5	5		
11	9	9	5	2	9	?	5	4		
12	9	0	5	4	9	0	5	5	Th —	
13	8	6	5	2	7	5	5	4		
14	9	0	5	3	9	0	5	4		Hy Hy
15	9	0	5	3	9	0	5	4		
16	9	0	5	3	9	9	5	3		
17	9	7	5	2	11	10	8	4	Th Th	
18	9	0	5	3	10	9	6	5		
19	9	8	5	3	11	9	7	5		Hy —
20	9	7	5	2	8	6	5	4	Th Th	
21	11	9	7	5	9	7	5	5		— Hy
22	8	6	5	3	9	7	5	4		— Hy
23	8	6	5	2	9	7	5	3		
24	9	0	5	1	9	7	5	4	Th —	
25	9	0	5	4	10	0	6	4		
26	9	8	5	3	9	0	5	3	Th —	
27	7	5	5	2	8	6	5	3		
28	7	5	5	3	8	6	5	4		
29	10	9	6	4	9	7	5	4		— Hy
30	7	?	5	4	10	9	7	5		
31	9	0	5	2	9	0	5	4		

Nos. 28, 29, 30 and 31 have some white blood.

PALM FORMULAE OF 33 AYMARA INDIANS

1	7	5	5	2	7	5	5	3		
2	9	7	5	3	11	0	7	3		Hy Hy
3	9	0	5	4	9	0	5	5		
4	9	7	5	4	9	9	6	4		
5	10	9	7	2	9	7	5	4		
6	7	5	5	1	7	5	5	4		
7	8	6	5	2	9	7	5	4	Th —	
8	7	5	5	2	7	5	5	3		
9	7	5	5	2	8	6	5	4		
10	10	9	6	4	11	0	7	5		
11	8	6	5	3	9	7	5	4		
12	7	5	5	3	7	5	5	4		
13	9	7	5	3	10	0	5	4		
14	8	7	5	3	7	0	5	3		
15	9	7	5	2	11	9	7	5		
16	7	5	5	4	9	0	5	4		
17	7	5	5	2	8	6	5	3	Th Th	
18	11	7	7	1	11	9	7	3		
19	9	7	5	4	11	0	7	5		
20	9	0	5	4	10	9	6	4		Hy Hy
21	7	5	5	2	8	6	5	3	Th Th	
22	9	0	5	2	10	0	6	2	Th Th	
23	7	5	5	3	7	5	5	4		Hy Hy
24	9	0	5	3	9	0	5	4		
25	7	5	5	2	9	7	5	4		
26	11	9	7	5	11	9	7	5	Th Th	
27	9	0	5	3	9	0	5	4		
28	9	7	5	3	9	7	5	4	Th —	
29	7	5	5	3	9	7	5	4		
30	9	8	5	2	11	0	7	4		Hy —
31	7	5	5	4	9	0	5	5		
32	9	0	5	4	9	7	5	4		
33	9	0	5	3	9	0	5	3		

STUDIES ON THE FEMUR

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GENERAL CHARACTERS OF THE FEMUR IN THE MALE WHITE

In the course of some special investigations on the femur, not yet published, (Ingalls and Grossberg), a considerable amount of data of a more general nature has been accumulated. The work has since been amplified and extended in a variety of ways and it is the purpose of the present paper to put on record a part of these observations together with some of the conclusions which may be drawn from them. Certain special features of the femur have been reserved for future treatment, while others await the collection of additional information.

Our attention was attracted to this subject some time ago by a pair of femora, and corresponding leg bones, in the Hamann Museum of Comparative Anatomy and Anthropology. Both femora and tibia, but particularly the former, present certain very unusual characters, a full discussion of which will appear later (Ingalls and Grossberg). An extension of our studies from a limited part to the entire bone was quite unavoidable and seemed all the more necessary since much of the literature on the subject deals only with relatively short series of bones, and moreover with series in which other important data are more or less uncertain if not entirely wanting. We refer to the race and sex of the individual whose bones may be under consideration. Fortunately we have not been compelled to labor under this handicap nor have we been restricted in the number of bones available for study.

The material which forms the basis for the present work is a part of the human osteological collection of the Hamann Museum and comprises one hundred (100) pairs of femora, known pairs and of known sex and race; in the present series, male, white. Sufficient evidence of the accuracy of these statements is furnished by the source of the material, the dissecting room. The series was limited to 100 on account of the great amount of time and labor involved in the investigation, although in certain cases this number has been considerably exceeded. One hundred white males are represented in the series but for some purposes one might look upon it as a series of 200 bones, and in any case

Am. J. Phys. Anthrop., 1924., Vol. VII., No. 2.

it may be considered as a fair sample of the entire material available. The bones were taken from the collection for the most part in order of their serial numbers. There has been no selection except that all the bones were from male, white bodies and only these cases have been used where both femora were in a condition which permitted the taking of all the measurements. Frankly pathological cases, healed fractures etc., were of course rejected.

In addition to using a series of fair length and purity, we have endeavored to further enhance the value of the results, especially for comparative purposes, by employing methods which are well recognized and also by giving in detail our own technique. In this we have followed quite closely the method of treatment employed by Karl Pearson (1919) in his recent monumental work on the femur. He repeatedly bewails the fact that the same measurement may be taken in different ways with varying results and also that too often investigators have not given adequate explanations of the methods of which they have made use. Pearson's measurements are numerous and elaborate, and his whole work gives evidence of a most patient and painstaking exactitude. Regardless of what one may think of the use to which he puts his results, one cannot well doubt their accuracy or be often uncertain as to the method of procedure involved in determining them. Many of Pearson's measurements we have not taken while several appear below which are not in his list. In the main we have followed Pearson's methods but where there is any discrepancy, or where the instruments, rather than the method have been different, this will be noted. A few measurements have been taken following other writers, and several new ones have been introduced for special purposes. Most of these latter ones, however, do not appear in the present communication.

The twenty-four femoral characters which will be considered at this time are given below, they appear later in the same order in the tables.

MEASUREMENTS AND METHODS

1. *Maximum Length.* Taken with the bone lying on the osteometric board, greatest possible reading between internal condyle and head, swinging bone from side to side until this is attained.
2. *Oblique Length.* Osteometric board, both condyles in contact with the vertical foot board, reading of plane parallel to foot board and tangent to head.
3. *Trochanteric Length.* Calipers. Greatest distance between top of great trochanter and external condyle.

4. *Oblique Trochanteric Length.* Taken like 2 but to the top of the great trochanter instead of the head.

A digression is necessary at this point in order to make clear some of the measurements which follow. Pearson (b. c. Pt. I. pg. 19) determines three points on the bone and then brings these three points into one horizontal plane. These points are; C. the center of the head, defined as the mid-point of the arc in which the plane, passing through the axes of the shaft and neck, cuts the head. While this procedure would locate the point C somewhere on the arc just noted, we do not see how it is always possible to take the midpoint of this arc as the center of the head. The head, and particularly its articular surface, may be placed quite excentrically upon the neck, more frequently above than below. In such cases the selection of a point as the center of the head must be made with regard to the neck rather than with regard to the head. What we have done, and Pearson seems to have done substantially the same, although it is not apparant in his account, is as follows. A second plane, also through the axis of the neck, but at right angles to the one noted above, would intersect the first plane on the surface of the head at the desired point C. It will be noted that nothing is said about the determination of the axis of the neck. As far as we can gather Pearson has determined the point in question by what, in other connections, he has termed appreciation. In other words the axis of the head and neck is determined after the location of one of its ends, the point C. Although Pearson states that it is easy to find the midpoint of the arc with a tape, he does not mention the limits between which he takes his midpoint. Presumably these are the borders of the articular surface, but as noted above, we do not think that this is always permissable.

For our own series then, we have marked the point C on the head, by appreciation rather than by actual measurement, at the intersection of the two planes through the axis of the head and neck, on the surface of the former. The *provisional* determination of this axis, in order to find the point C, is again by appreciation. We have drawn on the head two short lines, as representing the arcs of the two planes used; their intersection is the point C. It is difficult to see how some such procedure can be avoided in the determination of the axis of the head and neck. Other investigators have been faced with the same problem and have relied on appreciation to an even greater extent.

However, this is the only point on the bone which has been determined in this manner.

Pearson's second point, O, C being the first, is readily found as the lowest point, with the bone inverted, of median groove of the trochlea, between the condyles.

His third point is described as the "median point of the top of the great trochanter." This is none too clear but we have interpreted it as bringing the axis of the head and neck into a horizontal plane. We have located this third and last point by drawing a line from C, the center of the head, through the axis of the head and neck as viewed from above, this line projected cuts the great trochanter and gives the point desired.

With the bone so adjusted that these three points lie in one horizontal plane, Pearson finds the midpoint of the minimum vertical diameter of the neck. This when connected with C gives a projection of the axis of the head and neck. In like manner, with the bone still in the same position, the midpoint of the shaft at the level of the platymeric transverse diameter is located, which, when connected with the point O below, gives a projection of the axis of the shaft. The intersection of these two projections, of the axis of the head and neck and of the axis of the shaft, is termed the coaxial point, D, and the triangle thus formed, O D C, is Pearson's fundamental triangle.

Obviously this so called fundamental triangle merely brings the axis of the head and neck and the axis of the shaft, or, more strictly, their respective projections, into one plane. The essentials of the procedure, or rather the results desired, have long been commonplaces in femorology, but is remained for Pearson to give them something like scientific precision and hedge them round with much needed precautions. Much depends upon this fundamental triangle, especially as regards angles, hence the amount of space which we have devoted to it.

Our own method has been to adjust the bone on the osteometric board so that the points C, O and the mark on the great trochanter, all lie in one and the same horizontal plane. A number of small wooden wedges served the purpose very well. A second adjustment was made in order to bring the axis of the shaft as defined above, the line O D, parallel with the rulings (mm paper) on the board. With the aid a Parallelograph (Hermann), the points of which were made to register on the points C, D and O, marked on the bone, the location of these points was transferred to the mm paper of the osteometric board and there measured, after removal of the bone. In this way we have determined measurements Nos. 5 and 6, and, by means of a protractor, No. 34. Pearson made use of a contour tracer for No. 34.

5. *Capito-Collar Length.* The length of the head and neck, from the

center of the head to the coaxial point, the distance C D as defined above.

6. *Diaphyseal Length.* The length of the shaft from the summit of the trochlear pass to the coaxial point, the distance O D. This is obviously not the length of the diaphysis since it includes the lower epiphysis and excludes probably even more of the upper end of the diaphysis. It is naturally influenced by the angle between the neck and shaft, but is probably as satisfactory as other measurements which have gone under the same name.

8. *Platymeric Sagittal Diameter.* Minimum antero-posterior, infratrochanteric diameter. Smallest diameter, avoiding the gluteal ridge by measuring on its inner side. Sliding calipers, also used for 9, 10 and 11.

9. *Platymeric Transverse Diameter.* At level of 8 and at right angles to it.

10. *Pilasteric Sagittal Diameter.* The greatest antero-posterior diameter of the shaft in the region of the linea aspera.

11. *Pilasteric Transverse Diameter.* At the level of 10 and at right angles to it.

Pearson measures 10 and 11 by placing the bone on a horizontal surface and then measuring vertically and horizontally. The discrepancies would appear to be negligible.

12. *Least Sagittal Diameter, Inferior Diaphysis.* This and the following measurement, 13, are taken from Martin (1914, pg. 924). Taken with Tasterzirkel (Hermann, Zürich) in the axis of the shaft and at the lowest end which will give a minimum reading. Care must be exercised that the calipers lie in the sagittal plane and that the points do not drop into depressions or foramina in the bone.

13. *Transverse Diameter at the Same Level.* Taken with sliding calipers at the level of 12 and at right angles to the axis of the shaft. With the bone on a horizontal plane, ventral surface uppermost, the bar of the calipers are held parallel to this plane. This measurement is somewhat similar to Pearson's Popliteal Width but is taken at a very much lower level on the bone. Pearson's line lies 4 cm. above the articular surface on the front of the external condyle while ours is only about 3 cm. above the upper limit of the articular surface in the midline and is not always exactly the same level. The 2 cm. distance used by Klaatsch (1901) is much nearer the level which we have used. This low level is of very considerable importance as will appear in another connection.

14 to 23 inclusive deal with special features which will not be considered at present.

24. *Vertical Diameter of the Head.* The greatest ventral diameter in the vertical plane passing through the axis of the neck. Sliding calipers.

25. *Horizontal Diameter of the Head.* The maximum diameter at right angles to 24, taken in the same way.

Pearson measures the head parallel with and perpendicular to the surface upon which the bone is lying. Our reason for this slight deviation from him is that we have felt that we would obtain a more accurately comparable series of measurements for different types of bones.

26. *Epicondylar Breadth.* Measured over the most outstanding points of the epicondyles, parallel to the infracondylar plane. Taken in the corner of the osteometric board, the inferior surface of the condyles being in contact with one vertical, the medial epicondyle in contact with the other vertical. A square in contact with the lateral epicondyle gives the proper reading. Pearson uses calipers and attaches considerable importance to this measurement "especially for sexual and racial differentiation."

The method we have used in making this measurement is well recognized and has the advantage of being quick and simple. However, we would direct attention to the fact that without slight modification, it does not always give accurate results. In a considerable number of cases, when the bone is placed in the corner of the osteometric board, it will be found that the median epicondyle is not in contact with the vertical. This is due to the prominence of the articular surface below, and the condition was noted in 8% of the present series, being usually bilateral. As a rule the median epicondyle projects considerably beyond the articular surface, but in the exceptions just noted the articular surface exceeded the epicondyle, from 0.5 to 2 mm., the mean excess being about 1 mm. In one instance, and here only on the left side, the lateral articular surface overlapped the corresponding epicondyle by about 1 mm., while the medial epicondyle was more prominent than the medial articular surface. The bone in question was one of the largest measured.

It is easy to obtain the correct measurement in these cases by inserting a piece of wood of known thickness between the medial epicondyle and the vertical. Without this correction the mean epicondylar breadth in our series would have been raised very slightly, not more than 0.1 mm., less than a half of the probable error.

27. *Inferior Articular Breadth.* In this we have followed Parsons

(1914). The bar of the calipers is in contact with the posterior surface of both condyles, the arms enclose the maximum breadth of the bone close to the articular surface. This is usually a little in advance of the bar of the calipers.

28. *Inferior Epiphyseal Height.* This is one of our own measurements. It has not yet proved as useful as we thought it would and it is given here for what it may be worth. It is taken at the time the epicondylar breadth is determined and is the vertical distance between the medial epicondyle, i. e. its most prominent point, and the infracondylar plane. It is a purely epiphyseal character, since the epicondyle lies below the epiphyseal line, and is subject to considerable variation. Being taken at right angles to the other measurements on the lower epiphysis, it diverges from these in several ways, and seems to be more closely related to the shaft measurements, approximately parallel to the axis of which it is measured.

29. *Projected Length of the Lateral Condyle.* The vertical height of the highest point of the lateral condyle above the plane tangent to the posterior surface of both condyles below, and the posterior surface of the trochanteric region above. This is Pearson's standard vertical plane. Measured by placing the dorsal surface of the bone against the long vertical of the osteometric board and a moveable square in contact with the top of the lateral condyle.

30. *Maximum Length of the Lateral Condyle.* Also known as the natural length. Distance between the same points as in 29, but taken with calipers. It is the length of a straight line between the two points. No. 29 is a projection of this line on the infracondylar plane and therefore may be more or less foreshortened depending on the varying position of the points of contact, the varying obliquity of line 30. We have not been able to follow Pearson when he states that the maximum length should invariably be less than the projected length, and our results deviate correspondingly from his. In fact our own figures are more in accord with his statement that the two lengths are very nearly equal.

31. *Projected Length* of the *Medial Condyle.* Measured in the same manner as 29. Pearson considers this of doubtful value and has not taken it.

32. *Maximum Length* of the *Medial Condyle.* Measured in the same way as 30. It is usually much greater than 31 and may even exceed 29 and 30.

33. *Angle of Obliquity.* The obliquity of the shaft. This is the angle between a perpendicular to the infra-condylar plane and the axis

of the shaft, both being projected on the same plane, the surface of the osteometric board. The bone lies in its natural position on the osteometric board, with the infra-condylar plane parallel with the cross rulings of the board. The position of the mid-trochlear point O, which also lies on one of the cross rulings, and of the coaxial point D are then located and transferred to the board as described above. The angle formed between the line joining O and D and a line perpendicular to the cross rulings, and running through O, was found with a protractor.

34. *Collo-Diaphyseal Angle.* Collar Angle. It is the angle O D C when the bone is in the position noted above for the determination of 5 and 6. We have so adjusted the bone that the axis of the shaft, the line O D, was superimposed above one of the longitudinal rulings on the osteometric board; then as in 33 we have transferred the points C and D to the board, point D falling on the longitudinal line, and with a protractor have measured the included angle.

35. *Torsion Angle.* Pearson defines this as the angle between the plane of the fundamental triangle and the standard vertical plane (v. s.). This is the angle which we have measured and yet our procedure would give very slightly different results. Without detailing Pearson's method, we may say that he measures the angle between the axis of the neck and the standard vertical plane as viewed parallel with the standard vertical plane and at right angles to the infracondylar plane. We have measured this same angle, viewed in the same plane, but in the axis of the shaft instead of perpendicular to the infracondylar plane. We have endeavored to measure what Pearson, in this connection, terms the true torsion. It is a minimal angle which, if projected on the infracondylar plane becomes greater. Pearson computes that the angle he has measured is about 0.2° greater than the true angle, where the obliquity of the shaft is 10°. Obviously we are dealing with the same disturbing factors as when measuring the collo-diaphyseal angle. Here again, although it is not stated, the angle to be measured is minimal, while the torsion is the disturbing element. If the collar angle were less than 90°, instead of greater, it would be decreased instead of being increased, unless the axes of shaft and neck lie, and are measured, in one and the same plane. This true torsion is apparently what most writers have intended to measure, although many have chosen, not a retro-condylar plane and much less a standard vertical plane, but a plane which passes through the epicondyles, or some other neighboring points which have been supposed to lie in the axis of rotation of the knee, or the centers of curvature of some part of the joint sur-

faces. The selection of the two lines which are to include the torsion angle, the methods employed in locating them on the bone, and the relations of the plane upon which they are to be projected and measured all open up fruitful sources of error and discrepancy. Any comparison of torsion angles is therefore often entirely out of the question.

If the difference between the two torsion angles as computed by Pearson were sufficiently great, the angle which he has measured might, from a functional standpoint; have something in its favor as what might be termed the physiological torsion. A similar point of view may be taken in regard to the collo-diaphyseal angle. We have made a few attempts to determine what we had called provisionally the "natural" collo-diaphyseal angle. That is, the angle between the axes of the neck and shaft projected on the standard vertical plane, the angle as seen from in front, at right angles to the surface upon which the bone is resting. On account of the great variability of the torsion angle this "natural" collar angle would vary correspondingly, increasing constantly as the torsion angle increased whether positive or negative. The effect here would be far more pronounced than the effect of the obliquity of the shaft on the angle of torsion. The former angle varies in our series from 4° to 13.5° while the range of the latter is from +31° to -14° and we have seen it rise to more than +40° (No. 946). Since this altered position of the bone would have necessitated the redetermination of the axes of neck and shaft we have not followed the matter further. Roughly, the results seemed to indicate a variation of approximately 2° on a collar angle of about 130° and an angle of obliquity of the average amount. We are not yet sure that the determination of this angle would not be worth while.

In speaking of the torsion angle we are not concerned with the torsion of the shaft, as such, and no attempts have been made to measure it.

The angle in question, the torsion angle, we have measured as follows. Two points were marked on the bone, one, the center of the head, the second on the great trochanter, to both of these reference has already been made. The line joining these two represents the axis of the neck as seen from above, and lies in Pearson's fundamental triangle. The point on the great trochanter is not marked first, but is the point where a line joining the center of the head and the mid-point of the smallest antero-posterior diameter of the neck cuts the trochanter, this may or may not be its highest point. The bone to be measured was held by a spring clamp against a vertical board and adjusted so that the axis of the shaft was horizontal. A short distance below this vertical board was a horizontal shelf, accurately at right angles to the vertical board. On this shelf was placed a Stativgoniometer (Hermann). It follows from this arrangement that the plane tangent to the back of the great trochanter and the posterior surfaces of the condyels, Pearson's standard vertical plane, is perpendicular to the shelf below. The points of the arms of the goniometer were than adjusted to the ends of the axis of the neck, the center of the head and the point marked on the torchanter, and the angle read off on the scale. On account of a large collar angle, or low trochanter, the goniometer point over the mark on the trochanter may be at some little distance from the bone, and care must be taken that the two are in the proper relation, i. e. in a plane parallel with the board with which the bone is in contact. The goniometer upright must be kept parallel with the vertical board by means of its leveling screws. In cases of retro-torsion, or even minor grades of positive torsion, it is necessary to keep the head of the bone out of contact with the board by inserting strips of wood, of equal thickness and with parallel faces, between the board and the condyles and the board and the trochanteric region.

Reference may be made at this time to two other series of femora, also from the osteological collection. One of these, Grossberg's series, is made up of approximately 100 pairs of bones, male, white, of which 67 are included in our series of 100. Certain of the measurements in this series were taken by slightly different methods as will be noted later. A third series, designated as "All bones," included practically all of our series of 100, the total number varying for different measurements from 95 to 221. The average number for the thirteen characters represented is 172 right bones and 158 left, like the other series they are male, white, and the methods employed were throughout those used for our own series of 100. Comparisons within this last series lose some of their weight since the means were computed on a varying number of bones for different characters, while for right and left sides the material is not strictly paired.

The mean measurements of three series just mentioned and the number of bones involved, have been brought together in Tables IV and V for both right and left sides. There are also included similar data taken from Pearson's work, where the average number of bones for sixteen characters is 208 for the right side and 218 for the left. In Table III we have carried the comparison a little further, as far as computations have been made on the longer series, and include here not only the mean but also the standard deviation and coefficient of variation for five separate characters.

Table I. General Data. Male white femora. RIGHT.

No.	Measurement	Mean, in mm.	Standard Deviation	Coefficient of Variability	Range Max.	Range Min.
1.	Maximum Length	460.88 ±1.757	26.05 ±1.242	5.652 ± .270	539	406
2.	Oblique Length	457.83 ±1.731	25.67 ±1.224	5.607 ± .268	536	403
3.	Trochanteric Length	438.85 ±1.597	23.68 ±1.129	5.396 ± .258	509	387
4.	Oblique Troc. Length	436.32 ±1.582	23.45 ±1.118	5.374 ± .257	506	384
5.	Capito-Collar Length	77.31 ± .376	5.573 ± .266	7.209 ± .345	96	67
6.	Diaphyseal Length	390.93 ±1.550	22.98 ±1.096	5.878 ± .281	458	341
8.	Platymeric Sagittal	27.075 ± .127	1.885 ± .090	6.962 ± .333	34	22
9.	Platymeric Transverse	32.41 ± .199	2.948 ± .140	9.096 ± .437	39	24
10.	Pilasteric Sagittal	29.29 ± .150	2.221 ± .106	7.583 ± .364	35	23
11.	Pilasteric Transverse	28.13 ± .130	1.935 ± .092	6.879 ± .330	34	22.5
12.	Least Sag. Inf. Diaph	30.485 ± .200	2.973 ± .142	9.752 ± .469	41	24
13.	Trans. Same level	57.385 ± .386	5.724 ± .273	9.975 ± .480	74.5	45
24.	Head, Vertical	48.56 ± .172	2.550 ± .122	5.251 ± .251	56	42
25.	Head, Horizontal	48.3 ± .172	2.554 ± .122	5.288 ± .253	56	42
26.	Epicondylar Breadth	83.57 ± .260	3.849 ± .183	4.606 ± .220	91.5	70
27.	Inf. Art. surface Breadth	78.675 ± .257	3.814 ± .182	4.848 ± .232	90	69
28.	Epiphyseal Inf. Height	26.41 ± .126	1.872 ± .089	7.088 ± .340	32	22
29.	Lat. Condyle, Projected	65. ± .229	3.404 ± .162	5.238 ± .250	74.5	56.5
30.	Lat. Condyle Maximum	65.85 ± .233	3.457 ± .165	5.250 ± .251	75.5	57
31.	Med. Condyle Projected	61.245 ± .228	3.377 ± .161	5.513 ± .264	68.5	53.5
32.	Med. Condyle Maximum	64.33 ± .234	3.471 ± .165	5.396 ± .258	71.5	55.5
33.	Angle of Obliquity	8.63° ± .118	1.758 ± .084	20.371 ±1.011	12.5°	4.°
34.	Angle, Collo-diaphyseal	129.64° ± .452	6.701 ± .319	5.169 ± .247	152.5°	109.5°
35.	Angle of Torsion*	11.76° ± .531	7.872 ± .375	66.93	+31°	—5.°

*Computed with regard to sign, + or —. Mean of 92 positive angles = +12.607°. Mean of 6 negative angles = —2.666°. 2 = 0°.

TABLE II. General Data. Male white femora. LEFT.

No.	Measurement	Mean, in mm.	Standard Deviation	Coefficient of Variability	Range Max.	Range Min.
1.	Maximum Length	460.74 ±1.783	26.44 ±1.261	5.738± .274	534	406
2.	Oblique Length	457.87 ±1.777	26.35 ±1.257	5.755± .275	534	405
3.	Trochanteric Length	439.56 ±1.612	23.90 ±1.140	5.436± .260	509	388
4.	Oblique Troch. Length	437.3 ±1.613	23.92 ±1.141	5.470± .266	507	384
5.	Capito-collar Length	78.36 ± .397	5.883± .280	7.508± .360	97	66
6.	Diaphyseal Length	392.22 ±1.563	23.18 ±1.105	5.910± .282	459	342
8.	Platymeric Sagittal	27.11 ± .128	1.900± .090	7.008± .336	34.5	21.5
9.	Platymeric Transverse	32.465± .189	2.801± .133	8.621± .414	40	25
10.	Pilasteric Sagittal	29.415± .155	2.295± .109	7.802± .374	38	23
11.	Pilasteric Transverse	28.595± .148	2.192± .104	7.666± .368	36	22
12.	Least Sag. Inf. Diaph.	30.79 ± .193	2.870± .137	9.321± .448	41.5	25
13.	Trans. Same level	56.02 ± .394	5.840± .278	10.425± .502	77	42
24.	Head, Vertical	48.335± .173	2.571± .123	5.319± .254	55	41.5
25.	Head, Horizontal	48.055± .163	2.425± .116	5.046± .241	55	41.5
26.	Epicondular Breadth	83.345± .268	3.981± .190	4.776± .228	93	71
27.	Inf. Art. Surface, Breadth	78.29 ± .270	4.003± .191	5.113± .244	92.5	68
28.	Epiphyseal, Inf. Height	26.21 ± .138	2.044± .097	7.798± .374	32	22
29.	Lat. Condyle, Projected	64.6 ± .232	3.439± .164	5.323± .255	75	56.5
30.	Lat. Condyle, Maximum	65.64 ± .236	3.502± .167	5.335± .255	75.5	57
31.	Med. Condyle Projected	61.65 ± .230	3.418± .163	5.544± .265	70.5	53.5
32.	Med. Condyle Maximum	64.125± .235	3.479± .166	5.425± .260	73	55
33.	Angle of Obliquity	8.7° ± .130	1.926± .092	22.138±1.106	13.5°	4°
34.	Angle, Collo-diaphyseal	127.1° ± .495	7.346± .350	5.780± .276	145°	106°
35.	Angle of Torsion*	9.73°± .508	7.538± .359	77.47	+27°	—14°

*Computed with regard to sign, + or —. Mean of 90 positive angles = +10.355°. Mean of 8 negative angles = —5.125°. 2 = 0°.

Tables I and II give the results obtained by the applications of the methods outlined above, to the hundred pair of male, white, femora which constitute our principal series. Here are found the mean, standard deviation and coefficient of variation, with their probable errors, and the range, for each of the twenty-four measurements noted, both for right and left bones. Much of the following discussion is an elaboration of the findings brought together in these two tables.

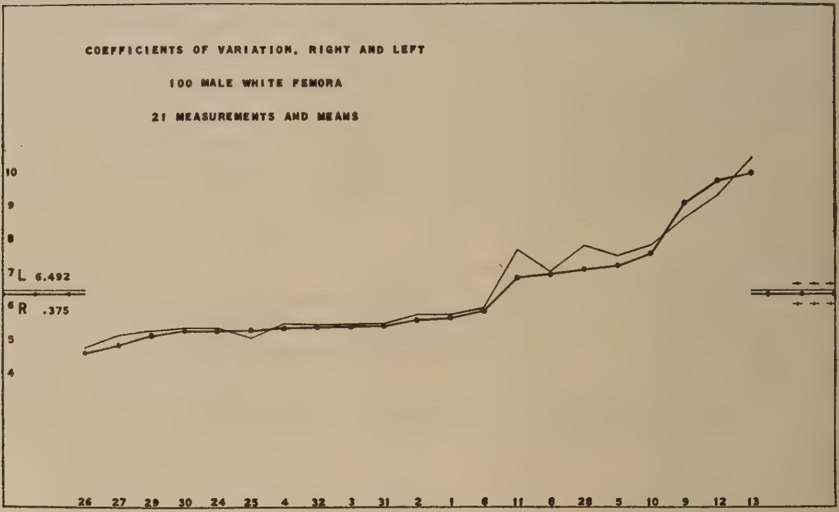
VARIABILITY OF THE FEMUR

In Graph I have been plotted the coefficients of variability of the right and left bones, they are arranged in the order of magnitude of the coefficients for the right side. This same order appears also in other graphs but in none are any of the angular measurements considered. From these curves it will be seen that the variability of the two sides is, on the whole, practically the same. The average coefficient for the twenty-one characters in question is 6.3755 for the right side and 6.4924 for the left. The difference between the two sides is not marked, is well within the limits of error, and, as it stands could hardly be considered significant. However, there are only three cases in which the variability of the right side exceeds that of the left. These are, 25, the horizontal diameter of the head; 9, the platymeric transverse diameter and 12, the least sagittal diameter of the inferior diaphysis. The first has a relatively low coefficient, the last two, and especially 12, are among the most variable parts of the whole bone.

TABLE III.
Comparative Data.
Male white femora. RIGHT.

No. of Measurement	Series	No. Cases	Mean	Standard Deviation	Coefficient of Variation
4	Ingalls	100	436.32 ±1.582	23.45 ±1.12	5.374±.257
	"	197	432.5 ±1.036	21.56 ± .73	4.985±.170
	Pearson	173	423.546±1.056	20.593± .747	4.862±.177
13	Ingalls	100	57.385± .386	5.724± .273	9.975±.480
	"	139	57.50 ± .324	5.673± .229	9.866±.403
24	Ingalls	100	48.56 ± .172	2.550± .122	5.251±.251
	"	126	48.45 ± .153	2.542± .108	5.247±.223
	Pearson	204	47.059± .136	2.887± .096	6.135±.206
26	Ingalls	100	83.57 ± .260	3.849± .183	4.606±.220
	"	221	83.20 ± .178	3.929± .126	4.722±.152
	Pearson	153	80.147± .219	4.025± .155	5.022±.194
28	Ingalls	100	26.41 ± .126	1.872± .089	7.088±.340
	"	206	26.20 ± .098	2.097± .070	8.004±.268

It may be further noted that in the portion of the curves below the average the two are extremely close together, and, except for 25, run practically parallel. At the opposite end, where the variability rises above the average, there are much greater discrepancies between the two sides, and in two instances the right is slightly more variable than the left. In this graph, and also in graphs 2, 3 and 5, the variability, using the right bone as the standard, increases progressively from left to right. The most marked differences between the right and left sides are shown by the pilasteric transverse, 11, and what we have called the inferior epiphyseal height, 28. We have not computed the probable error of the difference of the standard deviations of the right and left sides, but judging from Pearson's figures, the difference is two or more times its probable error for 11, and rather less than twice for 28. Otherwise the variations fall well within the limits of error. Taking the bone as a whole the difference in variability of the two sides is quite negligible.



Graph 1

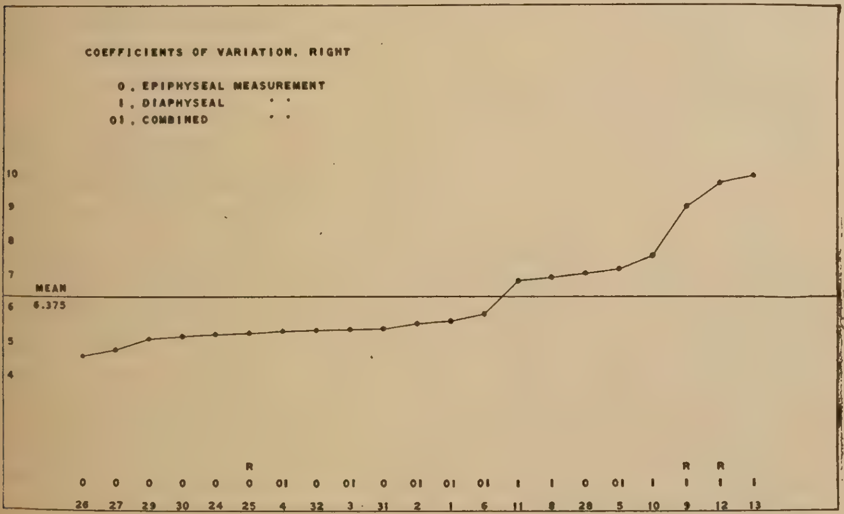
Graph No. 1. Comparison of coefficients of variation of the right and left femora from 100 male, white subjects. The right side is represented by the beaded line, the left by the plain line. At either end, the horizontal lines indicate the means of the right and left coefficients for the 21 characters considered. The short, interrupted line on the right represent the probable error of a coefficient of variation, having the value of the mean right, 6.375, for a series of 100. The numbers below refer to the individual measurements, see text and tables, they are arranged in order of magnitude for the right side. Along the left, as ordinates, are given the coefficients of variation.

In Graph 2 is shown another aspect of the question of femoral variability, the order of the characters remains the same but only the right side appears. Above each measurement number has been placed a symbol denoting its general character; 0 for a purely epiphyseal measurement, 1 for a purely diaphyseal, and 01 for any combination of epiphysis and diaphysis.

It will be seen that purely epiphyseal characters are grouped, for the most part, on the left, on account of their low variability. At the opposite end of the curve are located most of the strictly diaphyseal characters, while combined measurements appear scattered in between.

In other words there is a clear-cut distinction between the relatively constant epiphyses and the markedly variable diaphysis. Taken together, the epiphyseal features display remarkable uniformity while different shaft characters may differ considerably in their variability. Although the short, cross, diaphyseal measurements are distinctly more variable than the long, longitudinal, (combined) ones, the higher coefficients are by no means due to the smaller absolute values of the measurement taken. This disturbing factor is naturally unavoidable but may be safely discounted in view of certain comparisons. Measurements 11, 8 and 10 are all distinctly smaller than 9, while 12 has not half the value of 26, all in terms of mean values. The longest measurements of all, 1 and 2, fall in the center of the series.

There are, however, two or three rather conspicuous exceptions to the order outlined above, Nos. 28, 5 and possibly 31. No. 28, the inf. epiphyseal height, one of our own measurements, appears, on the surface, to be the most flagrant offender. Its rather high variability, regarding it as a purely epiphyseal character, and the considerable discrepancy between the two sides (Fig. 1), may find their explanation, in part at least, in the following considerations. In the first place it is not always easy to obtain an accurate measurement, since the most prominent part of the epicondyle, from which the measurement is made, may be rather broad or so flattened and uneven that the "point"



Graph 2

Graph No. 2. Coefficients of the right side in terms of epiphysis and diaphysis. Order as in No. 1. The three R's indicate the characters in which the coefficient is greater for the right side than for the left.

of contact becomes an area, sometimes several millimeters in extent. In such cases we have measured from the center of this area to the infracondylar plane. While determining the epiphyseal height we had anticipated a low variability and the effect of a small measurement in raising the coefficient of variation is possibly more in evidence here than anywhere else. A second explanation would be that this particular determination on the epiphysis, since it is taken in line with, or parallel with the shaft or combined measurements, and at right angles to all the other lower epiphyseal characters, might tend to vary with the former rather than with the latter. This being the case it would be found with the diaphysis rather than with the epiphyses.

Seitz (1923) has recently made somewhat similar observations on the epiphyses of the tibia and humerus. The nature of his material is uncertain both as to race and sex. Measurements were made on sections of the bone which exposed the epiphyseal line, when present. In order to compare his results with ours, but necessarily on a different bone, we have made certain calculations, basing them on his figures. For 29 right tibiae we find a mean of 373 mm., a standard deviation of 25.49 and a coefficient of variability of 6.834. The mean height of the proximal epiphyses in the same cases is 11.4 mm., its standard deviation 1.40 and the coefficient of variability is 12.298. In both instances the standard deviation and variability are high, due largely to the shortness of the series. But we feel that there is even more than this required to explain the variability of over twelve, The upper epiphysis of the tibia may very well be as variable as would appear from this, but other factors may also be involved, among them the short absolute value of the measurement. Our coefficient for the distal epiphysis of the right femur is 7.088, and slightly higher than this for the left bone. The results on 206 right bones, Table III shows a slight decrease in the mean measurement, a considerable increase however in the standard deviation and consequently a marked rise in the coefficient of variation. This is the only case where we have found that a greater number of measurements has resulted in any significant increase in the variability. In any case, as compared with other epiphyseal features, these epiphyseal heights, so-called, are quite definitely variable quantities.

Seitz has determined the percentage value of the epiphyseal heights in terms of the length of the bone. The average percentage value of the proximal epiphysis of the humerus was 5.58, ranging from 4.15 to 7.06. The average for the upper epiphysis of the tibia was 3.12 percent; for the lower, 2.29 percent. Our hundred right femora give 5.73

percent for this value. This is *not* the mean percentage but was computed from the two means.

There is then a very marked difference in the variability epiphyseal characters depending upon the direction in which the measurement is taken. This holds true for certain bones and may well have a more general application. The fact that dimensions taken in one plane show very much greater constancy than those taken roughly at right angles to this plane, certainly deserves something in the way of explanation. Even if this holds only for certain bones, or for certain epiphysis, the only effect would be to make the question a little more pointed. We are discounting at present, and we think with safety, any exaggerated variability due to the small dimensions or the difficulty of exact determinations.

Returning to the distal femoral epiphysis and to our own series, the tables show that six measurements, involving nothing but the epiphysis, nos. 26, 27 and 29 to 32 incl., show a mean variability of 5.170 for the right side and 5.253 for the left. These magnitudes may be contrasted with the variability of the epiphyseal height, taken at right angles to the other six—,7.088 on the right, 7.798 on the left. These differences are roughly of the same order as those which separate purely epiphyseal and purely diaphyseal variability.

The foregoing considerations are obviously a part of a larger and more general problem, the significance of epiphyses. Speaking now only of the femur, and again only of the lower end, we have noted the comparative constancy of the epiphysis, the definite variability of the diaphysis and the further fact that the epiphyseal height is almost as variable as the shaft. It is evident that the functionally important characters of the epiphysis, i. e., those features which stamp it as one of the essential components of a very complicated and highly important joint, are being kept within rather narrow limits. Surprisingly narrow in fact, when one remembers the varying configuration of the distal articular surface of the femur. On the other hand there would appear to be no such call for constancy in a dimension, or form, which are much less intimately related with functional requirements.

Seitz found little or no correlation between the length of a bone and the length of its epiphyses, and the same is true for the lower end of the femur. There is no reason to expect any correlation between these characters. Any adjustments for length of entire bone with which we are dealing primarily, may be taken care of either by the diaphysis or the epiphysis, in general probably by the former, but is difficult to see why there should be any correlation necessary. We have used the term adjustments for length in this connection, excluding thereby the normal growth in length. Other adjustments, than for length of bone, may very well be brought about at, or near the epiphyseal line, but additional determinations would be necessary before anything definite would begin to appear.

Basing our opinion on the accompanying data and also upon our experience with several hundred femora, we would say that the bulk of the adjustments, or adaptations in the femur, are cared for by the diaphysis rather than by the epiphyses. That they may be much more conspicuous in the diaphysis is quite obvious, and the conventional measurements may be much better fitted to bring them out here rather than in the epiphyses. In speaking of the low variability of the epiphyses, we are naturally relying solely on our own measurements, which are the usual ones. There is doubtless enough adjustment, and quite possibly enough variation also, in the epiphyses; but the character and extent of these await the application of finer and more elaborate methods. Nevertheless, the shaft must bear the chief burden in adjustments of the entire bone to various and varying conditions. For joints, or articular surfaces, important adjustments may be effected merely by slight movements, which leave little or no evidence behind them. Being more or less freely movable, they thus often escape the need of structural or formal alteration, which changes would be unavoidable elsewhere in the bone. Not only are most of the adjustments made in the diaphysis, but further most of them probably can, or must be made there. We would repeat that we do not consider the epiphyses as eternal and unyielding as might appear from the above statements and also that we are considering only those features which are included in our series of measurements. Further, for the present at least, we are speaking of the *human* femur only.

Referring again to Fig. 2, a few words may be said about 5, the capito-collar length. Although not as much out of place on this curve as 28, it has the added interest of being the character whose coefficient of variation is farthest removed from Pearson's, (Fig. 3). As far as its variability is concerned it is evidently more closely related to transverse measurements, like 9 and 11, than to the long, combined measurements with which it has been classed.

A number of factors may be noted any or all of which might be instrumental in increasing the variability of the capito-collar length. Technically there may well be certain discrepancies due to the method of determination. (v.s.pg 210). It is also the shortest by far of any of the combined measurements. Its mean value is almost identical with 27 the inf. articular width, which is found near the lower end of the series; but its coefficient show an excess of 50 percent over that of 27. As a specialization of the transverse diameter of the femur at its proximal extremity, and the head, and neck if present, are nothing more than this when they make their first appearance, this part of the bone may still retain one of the characteristics of the cross dimensions of the shaft, viz. their variability. For this reason, as a transverse specialization, we have just made the comparison with transverse characters, 9 and 11, rather than with those taken in a sagittal plane, 8 and 10.

Another possibility is that the same influence is at work as in the case of 28 (v.s.). Namely the measurement of an epiphysis at right angles to the other measurements on the same epiphysis, and in line with the axis of the adjacent shaft. To be sure, in all the long dimensions this same element enters, once or even twice, but its effects are almost, if not completely masked by the relatively great magnitude of the total determination. It may be mentioned in passing that the coefficient of variation falls often very considerably, in a variety of combinations; as between any femoral length, 5 or over, and standing height 3.75 or between sitting height, 3.91, and standing height. (Pearson, 1897, l. c. vol. 1, p. 311)

We have no measurements whatever on what may be called the epiphyseal height of the head, as far as it may be involved in the capito-collar length. Some information however may be gained from the determinations of Seitz (C. c.) on the head of the right humerus in 44 cases. We find from his data a mean epiphyseal height of 18.2 mm., a standard deviation of 1.633 and a coefficient of variability of 8.974. The mean length of the 44 humerus was 325 mm. We have not computed the variability of the entire bone, but Warren ('97) gives a coefficient of 5.216 for the maximum length of 62 right humeri from his Naqada material, and quotes a coefficient of 4.659 for 50 cases in Rollet's French series. There is, then, a very marked difference in variability between the length of the humerus and length of one of its small components, the same condition was noted above for the tibia. The capito-collar length may be placed in the same class, but here the small value of the total length is not sufficient to keep its variability within average limits.

Finally, aside from the foregoing considerations, the head-neck length, as an obviously very important character of the femur, may be possessed of a considerable variability brought about in other ways. All things considered it is, perhaps, not far from its proper position on the curve.

The projected height of the medial condyle, 31, hardly needs an explanation, it is omitted in Pearson's list, and, along with 32, the maximum length, is very slightly in excess of the value for the lateral condyle, 29 and 30. As regards the long combined measurements, 1, 2, 3 and 4, we would only note the fact that the oblique measurements are a shade lower than the maximal ones, and the trochanteric lengths less than those involving also the head and neck. The diaphyseal length, is a little greater, ostensibly a purely diaphyseal dimensions it must be subject to considerable variation, probably even more than 5, on account of the manner in which the measurement is taken. Martin's method (l. c. p. 923) while it excludes the lower epiphysis, does not take in all of the proximal part of the diaphysis and is open to criticism on this account.

If measurements of epiphyseal heights are of any importance, they will retain this only when there are satisfactory determinations of diaphyseal lengths. For the femur one could measure, parallel with the axis of the shaft, from the upper border of the articular surface on the lateral condyle, or possibly in the midline, below, to the lowest point on the superior aspect of the neck, close to the great trochanter, above.

Excepting 28, which has been discussed above, it is found that all the epiphyses are below the average variability for the entire bone, and that all the purely diaphyseal characters are above this average. The absolute magnitude of the measurement cannot, however, play a very great role, as may be seen from a comparison of 13 and 8 which are the largest and smallest dimensions involving the diaphysis alone. Again, 13 at the high end of the curve is taken transversely across the diaphysis only a little above the level of 26, the epicondylar breadth, which, however, is at the opposite end of the curve. This is the most striking example of the relative variability of the epiphysis and diaphysis, the coefficient of 13 being more than twice that of 26. The first graph shows also how the variability of the right and left bones runs practically parallel for the epiphyseal and long combined measurements, while for the purely diaphyseal features there is much less harmony.

COMPARATIVE VARIABILITY

For purposes of comparison, as regards variability, we have only the works of Pearson and Warren. Pearson's results are very important here since we have followed his methods in most instances, and in any case the findings in the two series should be quite closely comparable. In addition we have followed his example in working up much of our data. Pearson's material was, he states, derived from what were probably seventeenth century plague pits. The date is very uncertain, as is also the character of the population which placed here so many of its members, if not its representatives.

It is evident that a momentous question would arise in the sexing of the material, as far as we are concerned, the femur. Only individual bones could be considered, no reconstruction of skeletons, no help from other bones as crania or pelves. Pearson appreciates the difficulties fully and consequently devotes considerable space to the question of sexing the femur, (l. c. Part I, pgs. 40–61). He recognizes and relies more or less upon two methods of sexing. One is the anatomical, the opinion of the anatomist colored in part by the varying importance which different observers may attach to different femoral characters. On the other side is the "mathematical" sexing, in which he relies upon the absolute value of four characters. These are the vertical diameter of the head, the popliteal length (which we have not determined); the epicondylar breadth and the oblique trochanteric length, no angles being considered. On the basis then of a determined range of values for each of these features, a bone may fall into any one of five classes; definitely male, doubtful male, sex equivocal, doubtful female and definitely female. Pearson is careful to point out that his figures are applicable only to his own material, since racial differences may outweigh sexual differences, and that it would be necessary to deduce afresh for other material, these "mathematical rules." His opinion is that anatomical sexing is dependable if "based, not on one or two individual characters, but on a general anatomical appreciation;" but that it is inferior to the mathematical method. Both methods, he believes, will be found in substantial accord if based upon sufficient evidence. For a more detailed exposition of the arguments, we must refer the reader to the original.

We do not care to enter upon any discussion of this question at present, but is has seemed necessary, since our own series is restricted to male bones, to give some indication of the grounds upon which Pearson has sexed his material. For the femur this was "according to the general anatomical appreciation of sex." Warren was faced with a like difficulty with his Naqada material, and solved it in essentially the same way, but he had the additional advantage of dealing with more or less complete skeletons. There always remains, however, an unresolved residue of doubtful bones.

Another difference, which may or may not be of much moment, between our own, particularly the series of 100, and Pearson's series, is that our own results are based upon an equal number of right and left bones, known pairs from 100 individuals. In Pearson's material the number fluctuates considerably for different characters, to a less extent for the two sides, while there is nothing to indicate how many individuals might be represented. For these reasons his comparisons of right and left lose some of their value, some of which loss, however, is doubtless offset by the length of the series.

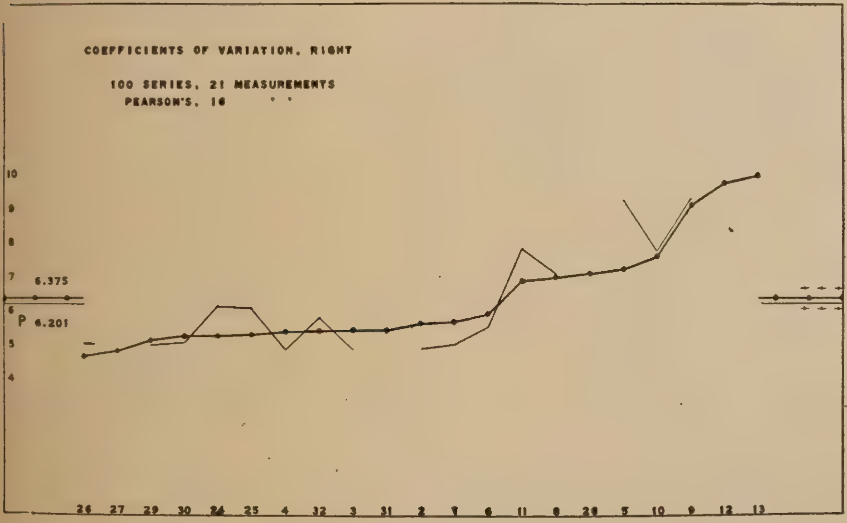
The mean value of Pearson's coefficients of variation is very slightly higher on the right side, while ours show a more definite excess in favor of the left. There is also less uniformity in this excess in his series, where out of sixteen cases, eight are greater on the right, and eight on the left. The same sixteen items in our series show fourteen greater on the left against two on the right. Both series show greater discrepancies between the two sides, in the cases of greater variability, but ours are much more nearly restricted to these cases, and, as noted before, to the strictly diaphyseal characters. For the sixteen items in question our mean variability is a trifle lower than Pearson's, 6.042 against 6.201, but this is within the limits of error.

It might be objected that it is unfair, or presumptive, to set up what appears to be an arbitrary arrangement, and then compare the data of other investigators with it. Naturally the essential results would have remained the same in the end if the opposite procedure had been adopted. We have chosen our own right side as a standard because it was slightly more constant than the left, and believe that this, and the order which obtains in most of the graphs, are justified by the results which appear best when set forth in this way. Pearson's figures would give in general the same information but not quite so clear-cut.

To avoid any uncertainty, we would remind the reader that throughout this article we are considering only *male* bones, and right or left as may be noted.

In Graph 3 have been plotted the coefficients of variation of the right side for our own and Pearson's material. It is true that the deviations are not great, but taken in terms of femoral characters and in conjunction with the mean measurements they become more significant. It is not so much the mean values as the behavior of the individual characters which is of interest.

All of the long, length measurements, 1, 2, 3 and 4 are uniformally below ours, and in three of these, all except 1, Pearson's left like ours is the more vairable. The capito collar length, 5, which has already been discussed at length, exhibits a greater deviation than any other character, his being much the greater and well outside the limits of error. His diaphyseal length, 6, is so close to ours as to require no comment, it is, however less. As for as length of femur is concerned Pearson's material would appear to be rather the more homogeneous, but his head-neck length, especially on the right side, is singularly at variance with this. Our greater value, of about the same order, is for the left side. It is possible that methods of technique are among the disturbing factors in this instance.



Graph 3

Graph No. 3. Comparison of right coefficients of variation; series of 100 and Pearson's series (ave. no. 208). Pearson's mean, 6.201, is for 16 measurements only. Our mean coefficient for the same 16 right measurements is 6.042. The lighter, more irregular line represents Pearson's series, where 27, 31, 28, 12 and 13 do not appear. Order as in graphs 1 and 2.

In view of their greater variability, the diaphyseal measurements, 8, 9, 10 and 11, run surprisingly close together in the two series, in fact more closely than the rights and lefts for either series taken alone. For the left side the two series are rather less in accord. The pilasteric transverse, 11, shows a rather marked scattering of values for the two sides in both series. Our left deviates from the right almost as much as Pearson's right, while his right and left are definitely closer together.

In view of their relatively low variability, the epiphyses of the two series are rather more divergent. Nos. 29 and 30, which concern the lengths of the lateral condyle, are a very little below the 100 series, while all the other epiphyseal characters are distinctly high. This is true particularly for 24 and 25, the vertical and horizontal diameters of the head. The epicondylar breadth, 26, and the maximum length of the medial condyle, 32, are on the very borders of the limits of error. Pearson's coefficients for the head exceed ours by from three to four times their probable errors, the discrepancy being rather more marked on the right side. This seems to us one of the most striking deviations in the whole series, we shall refer to it again. Both series agree in making the horizontal diameter of the head on the left side the most constant dimension of the head, while neither series shows much difference for the diameters on the right side.

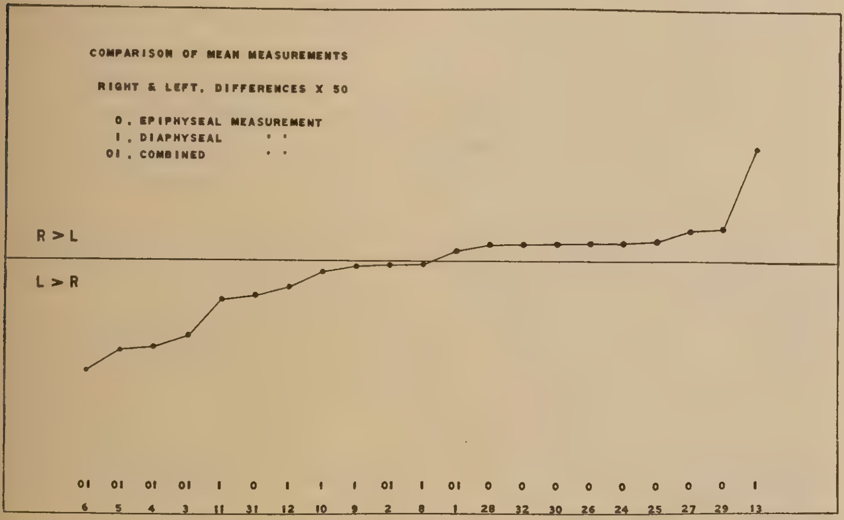
Regarding the variability of the three angles determined we shall add little to what is contained in the tables. The method of taking the angle of obliquity and the torsion angle are such that a very high and at the same time misleading coefficient results. They are therefore not comparable with the other femoral characters in this respect. The collar angle, 34, is much more tractable. Considering the magnitude of the figures our results agree quite well with Pearson's. Curiously enough, however, all of our coefficients are greater on the left side, while Pearson's excess is on the right; but both agree in finding considerable difference between the two sides, except for the collar angle. Pearson's differences are somewhat greater than ours. Doubtless the difficulty in making angular measurements, is responsible for some of the discrepancies and to some extent for the high degree of variability calculated. It would seem almost as if some personal equation were at work here, favoring in one series the right side, in the other the left.

Warren ('97), working on his Naqada material from Upper Egypt, ascribed to the 30th or 40th century B. C., gives coefficients for the maximum and oblique femoral lengths very close to ours. For eighty right male bones the values are 5.484 for the maximum, and 5.467 for the oblique length. Forty-eight pairs of male femora gave a coefficient for the oblique length of 5.458 on the right and 5.401 on the left. Unlike our own and Pearson's series, his higher value is in the right side. The coefficients for the eighty cases are much nearer ours than Pearson's.

MEAN MEASUREMENTS

In Graph 4 we have instituted a comparison between the mean measurements of the right and left sides. In Tables IV and V will be found the mean measurements of the three series of bones taken from the osteological collection and also Pearson's mean values. The means, with their probable errors are also listed in Tables I and II.

The deviations in these mean right and left values are not great, as a rule, and in order to bring them out to a better advantage in the graph, they have each been multiplied by fifty. Above the line are those characters in which the mean value for the right bones is greater than for the left, below the line are those where the left exceeds the right, the order being from the greatest excess on the left side to the greatest on the right.



Graph 4

Graph No. 4. Comparison of mean measurements of the right and left femora. Above the line are those characters in which the right bone exceeds the left, below, the reverse conditions. The order is from the greatest excess in favor of the left bone to the greatest excess for the right. Symbols below as in No. 2.

Here, as in Graph 2, there results a similar arrangement of the symbols below, but their order is, in large measure, reserved. The curve is also not unlike that in Graph 2. While the differences between the right and left bones are for the most part small, hence the necessity of increasing them all, the segregation of characters is quite as remarkable as in the case of the coefficients of variation. The fact that it was necessary to increase the difference fifty-fold in order to plot the smaller ones is ample evidence that the right and left femur have very similar values for their mean measurements. The most conspicuous feature in the graph is that all epiphyses, with the exception of 31, are slightly, but consistently, larger on the right side. No. 31, the projected length of the medial condyle might have been considered slightly out of place in graph 2, on account of its greater variability, as noted before this measurement was discarded by Pearson. No. 13 is the only purely diaphyseal character which is larger on the right, but this is the most variable item on our whole list. The epicondylar breadth, 26, may also have been a factor in determining its greater value on the right. As regards, 28, the epiphyseal height, discussed at length earlier in the paper, we could not have chosen a better place for it. Disregarding 31, it is the epiphyseal character which exhibits the greatest leaning toward the left side, i. e. toward the diaphyseal end of the curve, below the line. Its nearest relative, the pilasteric transverse 11, is near the opposite end of the curve, where the diaphysis shows its greatest excess for the left side. Again, as further evidence of the mean similarity of the two sides, 13 is the only case which shows a difference of more than three times the probable error, all others are safely within these limits. In general the greater diaphyseal dimensions on the left are of about the same grade as the epiphyseal excess on the right.

The diaphyseal length, 6, shows the greatest difference in favor of the left side, then follow the capito-collar length, 5, and the two trochanteric lengths 4 and 3. All these show rather definite higher means for the left bone. The maximum and oblique lengths, on the other hand, which include the head neck length and are influenced also by the angle of obliquity and the collar angle, are practically identical on the two sides. Some, at least, of this shifting of 1 and 2 away from 3, 4 and 6, may be explained by the rather larger collar angle on the right side, a mean excess of 2.5° over the left side.

On the whole there is no very great difference in the size and bulk of the two femora, what little there is being in favor of the left one. But this excess is evidently due to the greater length of the diaphysis, 6, and of the capito-collar length, 5. The diaphyseal length is obviously the more important factor as may be seen by the behavior of the trochanteric lengths. The cross measurements of the shaft contribute but little on account of their relatively low values. Much more striking than a slight mean excess on the left side, is that the left bone has a larger diaphysis, while the right bone shows the larger epiphyses. Neither of these features, however, is quite so clear-cut as the greater variability of the diaphysis, irrespective of side, as compared with the epiphyses.

Looking at the right and left bones from both points of view, we find a greater variability of the shaft for both right and left sides, but with greater values on the left side. The more constant epiphyses are larger on the right side. The left femur, although somewhat larger and more variable than the right, possesses slightly smaller epiphyses. The differences between the two bones are mainly diaphyseal in origin, both as regards absolute measurements and variability.

COMPARATIVE MEAN MEASUREMENTS

For comparative purposes we have little to draw on outside the other two series based on our own collection, and Pearson's material. Of the numberless scattered observations in the literature some of them series of fair length, we shall make little use. It has not seemed worth while for our present purpose, and this for the following reasons. The series are many of them too short, frequently only a few bones, while sometimes not even the number of specimens is stated. The methods employed in determining the measurements are not always given, the descriptions may be vague or the measurements themselves are so different as to admit of no comparison. Too little attention is paid to the nature of the material, to questions of right and left, sex and race. There may often be uncertainty as regards sex and stock, depending upon the source of the material, but for defective data, aside from this, there are no extenuating circumstances. To be sure, the nature of the individual problem may not render such details necessary, but their inclusion would have enhanced the value of the results, often very materially, and this at little added cost. Schwerz (1912) for example, in his rather extensive Alamannen material does not always distinguish between right and left, combines his male and female bones for the right and left means and his right and left bones for the means of the two sexes, even the number of cases is not always given. If anthropologists would read and take to heart some of Pearson's strictures, their data might accumulate more slowly but its value would be correspondingly greater and more permanent.

We may begin what little there is to be said by way of comparison, with a consideration of the two series already noted as Grossberg's and All Bones. Only in the former is there any difference in the methods employed. In addition to Tables IV and V, Graph 5 may be consulted in this connection. Comparing these two series with the series of 100, the question of side is immaterial at present, it will be seen that the differences, except in a few instances are entirely negligible. Some of the deviations were so slight that they could hardly be plotted even after being increased ten times. Only 1, 2 and 4 require any attention. These are the maximum and oblique lengths and the oblique trochanteric length. The greatest deviation is shown by 2, the oblique length for all bones, in this case the mean is for 217 right bones, but even this difference on more than twice as many specimens, is less than three times the probable error of the mean for the 100 cases of the same measurement. The three cases just noted show, but in rather exaggerated form, the

TABLE IV.
Cmparative Table of Means.
Male white femora. RIGHT.

No. of Measurement	100 Series Mean	Grossberg*		All Bones		Pearson	
		Mean	No.	Mean	No.	Mean	No.
1	460.88	457.9	99			446.771	218
2	457.83	455.3	"	452.8	217	444.351	202
3	438.85					426.064	187
4	436.32			432.5	197	423.546	173
5	77.31					77.037	227
6	390.93					377.980	"
8	27.075	27.06	99			26.831	236
9	32.41	32.85	"			31.678	"
10	29.29	29.38	98	29.27	134	29.534	237
11	28.13	28.39	"	28.35	"	28.023	"
12	30.485	29.89	99	30.40	139		
13	57.385	56.65	"	57.50	"		
24	48.56	48.65	"	48.45	126	47.059	204
25	48.3	48.40	"	48.17	125	46.597	180
26	83.57	83.55	"	83.20	221	80.147	153
27	78.675			78.45	204		
28	26.41			26.20	206		
29	65.			64.24	205	61.846	207
30	65.85					62.787	196
31	61.245			60.97	194		
32	64.33					62.110	203
33	8.63°	10.32°	98			8.686°	218
34	129.64°	123.95°	96			130.404°	227
35	11.76°	9.7°	95			11.628°	199
Average number of cases			98+		172		208

*67 of Grossberg's series are included in the 100 series.

Table V.
Comparative Table of Means.
Male white femora. LEFT.

No. of Measurement	100 Series Mean	Grossberg*		All Bones		Pearson	
		Mean	No.	Mean	No.	Mean	No.
1	460.74	458.7	100			447.700	225
2	457.87	456.1	"	453.5	220	445.481	214
3	439.66					425.553	209
4	437.3					423.456	194
5	78.36					77.212	229
6	392.22					376.203	"
8	27.11	27.02	100			26.646	247
9	32.456	33.17	"			31.524	"
10	29.415	29.47	"	29.30	140	28.674	250
11	28.595	28.87	"	28.69	"	27.950	"
12	30.79	30.19	"	30.61	139		
13	56.02	54.54	99	56.21	"		
24	48.335	48.52	100	48.38	95	46.769	212
25	48.055	48.16	"	48.02	"	46.375	196
26	83.345	83.32	"	82.97	219	79.404	166
27	78.29			78.03	184		
28	26.21			26.09	186		
29	64.6			64.15	185	61.048	209
30	65.64					62.091	193
31	61.65			60.95	127		
32	64.125					62.004	215
33	8.7°	8.56°	100			11.592°	233
34	127.1°	124.35°	"			131.474°	229
35	9.73°	9.49°	"			14.707°	210
Average No. of Cases			100—		158		218

*67 of Grossberg's series are included in the 100 series.

general tendency of larger numbers to bring down slightly the mean measurements. It will also be seen that this fall does not affect all characters nor is it much influenced by the relative variability. On the contrary it may be slightly more in evidence on the left of the graph, where the variability is least. Two characters, 11 and 13, with relatively higher variability have had their means increased instead of decreased.

The evidence from these two series as regards the difference between right and left bones is substantially the same as that shown in graph 4 for the series of 100. They tend, however, to accentuate even more the greater length of the left bone, especially as regards its oblique length. The two series are also in close agreement with each other. While the mean excess for right, or left as the case may be, varies somewhat in the three series, there are only two instances in which this excess has been reversed, i. e. being shown on the right side instead of on the left. The two cases in question (cf. graph 4), are 8, the platymeric sagittal diameter in Grossberg's series, and 31, the projected length of the medial condyle, in the series of all bones. In both cases there are disturbing factors which may in some measure account for this lack in harmony.

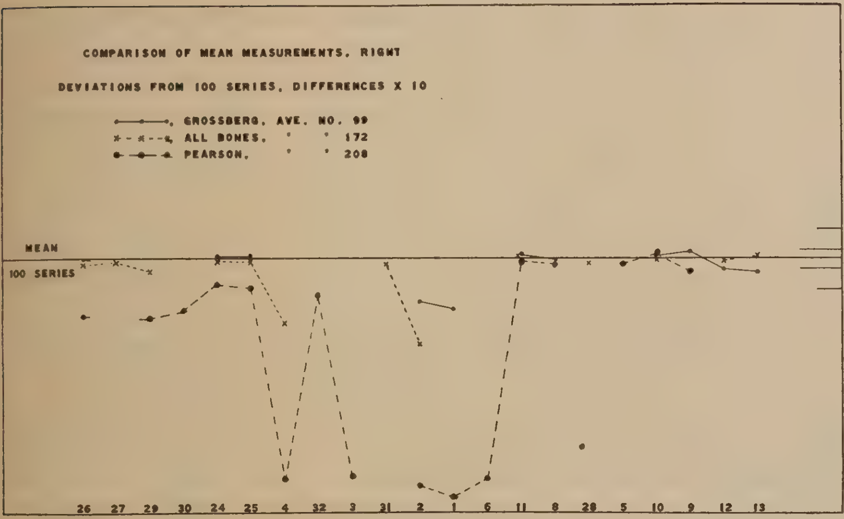
As regards the platymeric sagittal in Grossberg's series, we would first call attention to the fact this character, 8, is exceedingly close to the line in the series 100, while in Grossberg's cases it is above the line by about the same narrow margin. The platymeric sagittal diameter shows a smaller difference in these two series for right and left bones than any other femoral character. Grossberg, however, followed Martin (l. c. pg. 924) in the determination of his platymeric diameters; the transverse being measured first. This was taken at the widest subtrochanteric level, or, if this was not evident, at the point where the ridge running down from the lesser trochanter just ceases to affect the sagittal diameter of the shaft. The platymeric was then determined at right angles to the transverse and at the same level. In the method which we have used the procedure is exactly reversed (v. s. pg. —). The resulting difference in the two series is entirely negligible for the sagittal diameter, and only about half a millimeter greater for the transverse in Grossberg's cases. It is surprising that these differences should be so small where one method selects the least sagittal value as a starting point, the other the greatest transverse. There is in addition a considerable difference in the variability of the two platymeric diameters, the transverse, as one might expect, being greater. In view of the findings on our two series we had expected these two features to exhibit some appreciable correlation. Pearson, on his material, finds a correlation of +.237 ±.041 for 236 right femora and even less, +.091 ±.043 for 247 left bones, and believes that the higher values found for Hepburn's modern British, +.432 ±.084 for 43 cases, right plus left, are due to the heterogeneity of the latter's material. Pearson calculated his coefficients of correlation from the coefficients of variation. If I = 100 N/D be the index then

$$R_{ND} = \frac{V_N^2 + V_D^2 - V_I^2}{2V_N \quad V_D} \qquad \text{(l. c. p. 192).}$$

Using this method we have calculated the correlation of the platymeric sagittal diameter with the platymeric transverse, the resulting coefficient of correlation being +.164 for 100 right bones. According to this the correlation is less in our series, on the right side, then in any of the series cited by Pearson. The correlation appears to fluctuate considerably depending on side and sex, and our left side might give a different value, judging from the coefficients of variability, but we have not computed it. The platymeric region and the bone immediately above must be an extremely important part of the femur. It is here that the forces acting on the head, neck and trochanter are transferred to the shaft below, to a considerable extent to the pilaster.

Returning to the comparison of right and left within our combined series we had noted (p. —) that, in addition to 8 for Grossberg's series, 31, the projected length of the medial condyle in the case of all bones, had altered its position, showing in this series a slight excess on the right side. If we should accept this finding, rather than the results based on the 100 series, we would then have a clean record of all epiphyses being larger on the right side. We cannot place very much confidence in this, since the excess on the right for the series of all bones is extremely small. There is also a considerable discrepancy in the number of right and left bones measured, 194 and 127 respectively. On the other hand it is quite possible that an increase in the number of left bones, i. e. an equal number of both sides, would have lowered the left mean and so increased the small difference. In the series of 100, however, the equal numbers have had the opposite effect.

For the present, then, it seems necessary to accept the projected length of the medial condyle as rather aberrant; it being the only epiphyseal character which is larger on the left; it shows further, excepting 28, the greatest epiphyseal variability. In general the



Graph 5

Graph No. 5. Comparison of mean measurements of the right femur in four series of cases. The horizontal line represents the mean value for each character in our series of 100. The other series are plotted in relation to this, above or below as they exceed or fall short of the mean of our series. The two longer lines on the right indicate the mean probable error for the 21 mean measurements. The two shorter lines, also on the right, indicate the probable error of the largest mean, (No. 1), likewise of the 100 series. Only the series of 100 contains all of the 21 characters. Order as in graphs 1, 2 and 3.

median condyle is more variable than the lateral, Pearson's results accentuating this feature even more than ours.

Turning now to the mean measurements of Pearson's series we find a number of points of interest. (Table IV and V, and Graph 5.) Out of the 16 characters, where comparisons are possible, in only one case, and this on the right side, does his mean exceed ours, the character in question being the right pilasteric sagittal diameter. Much more striking than this, however, is the fact that where the variability is above the average, measurements 11 to 13 incl., the differences in the means are quite insignificant. From 6 to 26 on the opposite end, the variability is below the average, (cf. Graph 2), and it is here that the deviations between the two series are found. Looked at from another angle it will be seen that, as far as purely diaphyseal features are concerned, the differences between the two series practically disappear. In other words the material of the two series is differentiated mainly by epiphyseal and longitudinal shaft characters.

Although Pearson's series is much longer than our 100 series we believe that we can safely discount this as an important factor, in lowering his means. The behavior of our longest series, exceeding Pearson's for certain characters, points in this direction, while the evidence from the various indices can only be interpreted in this sense.

In all of the long, or combined, shaft measurements his means are far below ours, and there is little to choose between them. It is true the Nos. 2 and 4, from the series of all bones, are also somewhat lower than the series of 100, but these means were determined on a greater number even than were Pearson's. Evidently he is dealing with a femur which is definitely shorter than ours, but whose other shaft characters show practically identical values as far as they have been determined.

The epiphyses are of special interest. As noted before they are the least variable parts of the bone. Although Pearson's coefficients for various femoral lengths are lower than his epiphyses, the latter, on his own figures, are less variable than the purely diaphyseal measurements. In terms of the absolute value of the character, his epiphyses are even more divergent from ours than are the long, length measurements. Not only are his bones shorter than ours but the epiphyses, in other words, the joint ends, are smaller, smaller if anything than the smaller bone would lead one to expect. A very good example of this is the epicondylar or bicondylar, breadth, 26, the most constant femoral character according to our results, and also low down in the list of Pearson's variabilities. Even more marked, as indicative of a smaller joint, are 29 and 30, the projected and maximum lengths of the lateral condyle. More marked than 26 because they deviate quite as much in millemeters from mean of the 100 series, but this equal, absolute deviation concerns a very much smaller dimension, roughly 65 as against 83.5 mm. Not only are Pearson's knee joints narrower than ours but their lateral condyles are very much shorter.

As regards the median condyle we can compare only 32, the maximum length of the medial condyle. Although somewhat shorter than ours, it is distinctly less divergent than the lateral condyle.

The upper epiphysis of the femur, or a part of it, represented by 24 and 25, the vertical and horizontal diameters of the head, deviates from ours to about the same extent relatively, as the lower epiphysis. The absolute difference is less on account of the much smaller dimensions. The slightly greater divergence for the horizontal as compared with the vertical may be neglected for the present.

From the foregoing comparisons we conclude that Pearson's femora are distinctly shorter than ours, while the shaft is almost as massive. The articular ends are definitely smaller, not as large even as the other dimensions of the bone might indicate.

Further light on the comparative features of the two series is furnished by the range of the absolute values, only a few of these will be quoted. Pearson's bicondylar width ranges, on the right side from 71 to 89, ours from 70 to 91.5. On the left side his range is from 70 to 89 but with only three below 72 and three above 87. Our range for this side is from 71 to 93. The vertical of the right head in his series runs from 40 to 55, with only one case over 53. For this our range is from 42 to 56. His left head, also vertical diameter, gives values from 38, no 39, to 55 but with only one over 53. Our range here is from 41.5 to 55. The projected length of the lateral condyle is even more interesting. Pearson's, for the right side, range from 53, the only one below 55, to 69; ours are from 56.5 to 74.5. Like the two other characters just noted, this condylar measurement extends to lower readings on the left side than on the right. Pearson finds here a lower limit of 51, no 52, while the upper limit is 68 and there is only one of these. Our limits for this are from 56.5 to 75. It is in the lower values i. e. in the smaller joints, that Pearson's series deviate farthest from ours.

If we average the means of the 16 characters which it is possible to compare, we find that this average for our 100 right femora 172 mm., while in Pearson's material the average of the means in 167. The difference on the left side is a trifle greater. Most of this deviation is naturally due to his shorter bones.

Before making any further comparisons of mean measurements we would direct attention to the two longer lines on the right hand side of graph 5. As noted there, these longer lines, above and below the mean of the 100 series, represent the average, mean error, + or —, of the 21 characters considered. However, as indicative of the low values of Pearson's epiphyses, we would point out that the probable error of the means of the epiphyses is one-third only, or even less than this fraction of the mean error, as shown on the right side of the graph.

Further comparisons of mean femoral measurements will be rather brief. The reasons for this have already been given. Parson's Rothwell material, (Parsons, 1914) with which we shall begin, is described as the bones of mediaeval English from the thirteenth and fourteenth centuries. Out of a very large, but rather fragmentary collection, he has gathered together two series of femora, male and female, the average number being apparently not far from 100. The sex of the bones was determined largely from the size of the heads. His maximum and oblique lengths on the left bone are practically identical with ours, 460 and 456 mm., for 98 and 102 left bones. His right bones are very much shorter for these two lengths, being only 456 and 453 mm., but for a smaller number of bones, about 75. This very marked discrepancy in the femur lengths of the right and left sides seems to us very serious and, since his female series shows even greater differences, 6 mm., we can only conclude that his series of right and left are unrepresentative and consequently not comparable. Some of this excess is due to the presence of a very long left femur, 543 mm., which has no mate on the right to offset it. There is also the ever present possibility of errors in sexing. The differences between his oblique and maximum lengths, unaffected by these faults, is insensibly different from either our results or Pearson's.

In a later article (1915), based upon about 30 pairs of femora, known to be male, Parsons finds little or no difference between the oblique and maximum lengths on the two sides, while the excess of the maximum over the oblique, remains about the same as in his Rothwell series. The platymeric diameters are also much less aberrant here.

Parson's platymeric and pilasteric determinations are not strictly comparable with ours. For the former he measures the sagittal diameter first, but at what level is uncertain. The pilasteric measurements are apparently not taken at the same level, the sagittal selecting the greatest dimension, the transverse taking the least, the location of either may fluctuate very considerably. As a result of this one would expect his anteroposterior dimension to exceed ours, which they do by from 2–3 mm. However his least transverse exceeds our pilasteric transverse, by over a millemeter on the left side. While Pearson's femora have a relatively more massive shaft, relatively on account of the shortness of the bone, Parsons' cases are absolutely much more bulky and robust. Like ours his left bones show larger mean values. How far it is possible to compare his platymeric region with ours, we do not know. His figures would seem to indicate that the sagittal dimensions are not very divergent, although his excess for the left bone is even more marked than ours. 2 mm. against .64 mm. His transverse, subtrochanteric measurements are very high, 35 on the right and 36 mm. on the left, although like ours they differ less on the two sides then do the sagittal dimensions. Parsons' mean platymeric transverse is about midway between our mean and maximum. As Pearson remarks he must have found a pocket of very platymeric bones, or else his material is inadequate.

It is not possible to say just how Parsons has determined his maximum diameter of the head, but it may compare roughly with our vertical. It is slightly greater than ours, 49 mm., and as far as the data go, the same on both sides. This result seems to us rather high but it must be remembered that it was largely the size of the head which determined the sex of the bone. However, his more recent data (1915) give the same values.

In taking the breadth of the inferior articular surface, 27, (*q. v.*) we had followed Parsons' example if not his technique. Disregarding differences in method he finds this dimension to be 75 mm. on the right side and 77 on the left, the number measured being 68 and 92 respectively. These values are much lower than ours, especially the low reading for the right bone. Parsons considers this measurement of some importance in sexing the bone. His London material however shows a greater articular width, 79 mm. on both sides, slightly greater than ours.

The Rothwell series gives some rather bizarre results, the sampling cannot be considered adequate, or representative, and there may also be errors in sexing. The femora from this source show marked discrepancies between the two sides; they are of about the same length as ours, but they have a much more massive shaft, while the upper joint end is slightly larger than ours, the lower end is distinctly smaller. A curious combination,if possible.

Parsons' Rothwell material ranges from what we take to be 405 to 495, with one large straggler at 543 mm., our range is from 406 to 539. The width of his articular surfaces, probably both sides, runs from 68, with one at 65, to 84 with two more at 87. Our range including both sides is from 68 to 92.5. Parsons' London material is essentially the same for the articular width, his maximum diameters of the head, however, show a surprisingly narrow range, between 44 and 53.

In the account of the Lenape (Delawares) given by Hrdlička (1916) there is contained a considerable amount of data relating to United States whites. As far as the femora of males are concerned Hrdlička's findings agree very closely with ours.

The only conspicuous exception being the oblique length of the femur, our 100 series giving an excess of about 12 mm., the series of all bones an excess of 8 mm. over Hrdlička's whites. His Munsee (Lenape) femora are much closer to ours in length, closer for the maximum than for the oblique length. For white males he found a difference of 2.8 mm. in the two femoral lengths, our series shows a difference of 3. mm., also with a slightly greater difference on the right side, 3.07 mm. against 2.93 mm. As regards the platymeric and pilasteric dimensions, his white males, 66 cases, show no essential divergence from ours. Our left pilasteric sagittal is slightly greater than the right, while in his series the two are equal. Both series agree, however in giving the left side the greater transverse diameter of the shaft at this level. His platymeric diameters are rather closer to ours for the transverse diameters than for the sagittal, but the differences as regards side are reversed in both cases. In this respect, differences as to side, our femora are more like his Munsees and blacks.

Hepburn's findings (1897) in modern British femora, something over 40 in number, but without regard to side or sex, give a mean oblique length of 459 mm., slightly above ours, but the heads are somewhat smaller, 47.8 mm.

The investigations of Holtby (1918) are based on 56 male bones, 21 right and 35 left, sex and nature of the material not definitely known. In other words the bones were sexed. His results are so close to those obtained by Parsons on his Rothwell material that little more need be said, even the difference between right and left are quite as marked. His conclusion that short bones have relatively larger extremities than long ones, follows naturally from what we said earlier in this paper on the relatively low variability of the epiphyses. He is in agreement with us also to the effect that left bones are broader than right and that the head is more variable than the width of the lower articulation.

From Bumüller (1899) we shall quote only his maximal and oblique lengths, 450.16 and 445.4 mm. averages of 350 and 340 specimens, rights and lefts together. He finds for these dimensions and also for his diaphyseal length, a substantial excess in favor of the left side, differences ranging up to 3 mm. In spite of an apparently large amount of material his results leave much to be desired.

Schwerz (1912) gives an oblique length of 462.7 mm., for his Alamannen femora, this includes right and left bones but the number is not given. His means are distinctly higher than ours for the oblique length, while his epicondylar breadth is the same as ours, 83.4 mm. The increase of 5 mm. on the length has had no effect upon the width of the lower epiphysis. Pearson finds a correlation of +.596 ±.035. for the maximum length with bicondylar width on 151 right bones. The correlation is rather lower on the left side, and still lower for female bones. This value is apparently above the average of Pearson's femoral correlations. In 124 cases Schwerz finds that the left femora was longer than the right in 53.4% of cases, the two femora were equal in 16.9%. The particular measurement concerned, and the sex, are not stated.

For 48 pairs of male femora, Warren finds the oblique length to be

453.250 mm. on the right side and 454.500 on the left. His Naqada femora are about the same length as ours, possibly a little shorter.

Dwight's findings (1905) on the head of the femur, 100 males and 100 females, are not, probably, strictly comparable with ours for two reasons. He measured the maximum diameter simply, without reference to any particular axis and furthermore he measured all his bones with the cartilage still in place and in good condition. No distinction is made between right and left bones. His results on 200 femora give the mean maximum diameter of the head as 49.68 mm., including two layers of cartilage. Dwight estimates the excess measurement, due to the presence of the articular cartilage, at from 2–3 mm. and in this he is probably correct. Deducting this amount from his mean value, the heads of his femora appear distinctly smaller than ours, the apparent difference being nearly a millemeter and a half. The range of Dwight's material, including cartilage 42 to 56 mm., is practically identical with ours on dry bones, 41.5 to 56 mm., for both right and left, 200 heads as in Dwight's series. From this it is evident that the heads of our femora, including the cartilage, would have shown higher maximum and minimum values, corresponding with the higher mean.

Dwight did not measure the length of the bones upon which he took the head measurements. Using the data from Hrdlička's Columbia material 100 male white adults, he finds an oblique length 449.5 mm., no distinction as to side. The average length of his bones then, is rather less than ours, the head as just noted is also not as large. He does not believe that there were any great differences in the nature or sources of his and Hrdlička's material, and if ours is as comparable, we are dealing with slightly larger individuals. The range of the two series would also indicate this, 400–510 mm. in the Columbia material, 403–536 mm. in ours, in both cases for the oblique length.

Garson (1879) measured 70 pairs of femora and tibiae, of varying age, race and sex, in a manner however which is not comparable with any of our measurements. Instead of taking either the oblique or maximum lengths he substitutes something which is probably somewhere between the two. It is the length of the bone, between the medial condyle and the head, measured parallel with its long axis. He does not give means and his bones exhibit an enormous variation, from about 300 to well over 600 mm. In 41 of these 70 cases he finds that left femur exceeds the right by an average of 3.8 mm. In 9 cases they two were equal, while in only 20 did the right show an excess over the left, its average preponderance being 2.9 mm.

FEMORAL ANGLES

On this subject we shall present little more than is contained in the tables. Grossberg's determinations were made after Martins methods (l. c. p. 927) with slight modification. His technique was as follows: Angle of Obliquity: The middle half of the axis of the shaft was estimated with the eye and marked by a piece of black thread held in place by pieces of wax. The bone was then placed in its natural position with both condyles resting upon a horizontal surface. The angle was read off with an Ansteckgoniometer (Hermann) carried on slide calipers. The arms of the calipers were used 5 cm. apart and the points were placed in contact with the axial thread.

Collo-diaphyseal angle: The axis of the head and neck was marked also by a black thread joining the center of the head and the midpoint of the anterior intertrochanteric line. Both of these were determined by measurement, the former by means of calipers the arms of which were parallel with the neck. The axis of the shaft is already given by the thread used for the angle of obliquity. The angle included between these crossing threads was measured with a transparent protractor.

Torsion angle: The center of the head was determined as for the preceding angle, but as seen from above. A thread, attached to the bone at this point, was drawn taut by its free end and made to coincide with the axis of the neck as seen from above, this being estimated with the eye. The thread was secured in this position to the top of the great trochanter. With a protractor, the angle between this line and a line parallel to the surface upon which the bone is resting, was read off.

The tables reveal a rather curious condition. The angle of obliquity as determined on our series of 100, essentially in Pearson's manner, is practically the same for both right and left bones. Grossberg's results are quite different, his angle on the right being distinctly greater than ours while it is a trifle smaller on the left. His collar angles are both smaller than ours, our right being rather larger, while his left shows a very small excess. Grossberg's torsion angles are also in both instances smaller than ours, in both series the angle is larger on the right but our right exceeds his by two degrees. Only one of Grossberg's angles is larger on the left, the collar angle; only one of ours is larger on the right, the angle of obliquity.

In Pearson's series the three angles in question are practically identical with ours for the right side. His left angles, however, are uniformally greater than his right, and very considerably in excess of our left angles. We hesitate to draw any conclusions from these comparisons beyond the obvious lesson that the taking of comparable angular measurements is attended by very serious difficulties. As mentioned before one might find here signs of some personal equation or technical difficulty, favoring one side rather than the other. Parsons, whom Pearson criticizes severely for his technique in angular measurement, finds no differences in the angles for the two sides, except for the collar condyle, and the deviation is only one degree.

FEMORAL INDICES

As regards indices we have followed Pearson's formulae and also his terminology. In certain cases, where the data are not strictly comparable, we have omitted the indices. The results, on all of our series, has been brought together in Tables VI and VII, along with Pearson's indices for the same characters. In the column which gives the formulae for the indices, the numbers refer to the measurements as given in Tables I and II. In Tables IV and V will be found the number of cases upon which are based the indices for all bones. We would call especial attention to the fact that these tables give indices of means only, *not* mean indices. This applies also to our citations from Pearson. For comparative purposes, and also as a check on the value of our indices of means, we have calculated the mean index in four cases. These are the right and left platymeric and pilasteric indices. For the right platymeric index we have also calculated the standard deviation and the coefficient of variation. All of this additional information will be found in Table VIII.

Tables VI and VII reveal no very great differences in the three series based upon our own collection, the deviations being often very small. The determinations for the series of all bones are not quite so trustworthy as in the other two series, on account of the varying number of bones representing the two characters and also because they are, obviously, not strictly paired. The only cases which call for any consideration are Nos. 1, 2 and 8. These are the platymeric and pilasteric indices and what Pearson terms the first transversal ratio or the index of upper gracility. It will be seen that these involve the short, diaphyseal measurements, which, as noted before, are the most variable femoral characters and also the characters in which the variability of the two sides is most divergent. Grossberg's series shows a lower platymeric index, the discrepancy being somewhat greater on the left side. The pilasteric index behaves in essentially the same manner. As regards right and left bones, all series agree in giving greater values to the right

TABLE VI.

Femoral Indices. INDICES OF MEANS
Male, white. RIGHT SIDE.

No.			Formula	100 Series	Grossberg	All bones*	Pearson
1	Platymeric,	Index	8x100/9	83.54	82.37		84.70
2	Pilasteric	"	10x100/11	104.12	103.49	103.24	105.39
3	Bicondylar Width	"	26x100/1	18.13	18.25		17.94
4	Primary Capital	"	25x100/24	99.46	99.49	99.42	99.12
5	1st Capito-collar	"	24x100/5	62.81			61.09
6	2nd " "	"	5x100/6	19.77			20.38
7	3rd " "	"	5x100/26	92.51			96.12
8	1st Transversal Ratio Upper Gracility	"	11x100/9	87.52	86.42		88.46
9	1st Shaft I. Trans. slenderness	"	11x100/6	7.20			7.41
10	2nd Shaft I. Sag. slenderness	"	10x100/6	7.49			7.81
11	Direct oblique length	"	2x100/1	99.34	99.43		99.46
12	" " Trochanter	"	4x100/3	99.42			99.41
13	Secondary capital	"	24x100/1	10.33	10.62		10.53
14	4th Capito-Collar	"	5x100/1	16.70			17.24
15	Bicondylar Trochanteric	"	26x100/3	19.04			18.81
16	5th Capito-Collar	"	5x100/2	16.89			17.34
17	Condylar Trochanteric	"	30x100/3	15.02			14.74
18	Robusticity Femur	"	10+11x100/2	12.54	12.69	12.72	12.95
19	" Head	"	24+25x100/2	21.16	21.32	21.34	21.07
20	Condylar	"	30x100/26	78.80			78.34
21	3rd Capital	"	24x100/26	58.11	58.23	58 23	58.72
22	Condylar Lengths	"	30x100/32	102.36			101.90

**Not* exact, not same bones or same No. in two measurements.

TABLE VII.

Femoral Indices. INDICES OF MEANS.
Male, White. LEFT SIDE.

Index No.	100 Series	Grossberg	All Bones*	Pearson
1	83.50	81.46		84.53
2	102.87	102.08	102.13	102.59
3	18.09	18.16		17.74
4	99.42	99.26	99.25	99.16
5	61.68			60.57
6	19.98			20.52
7	94.02			97.24
8	88.08	87.04		88.66
9	7.29			7.43
10	7.50			7.62
11	99.38	99.43		99.50
12	99.46			99.50
13	10.49	10.58		10.45
14	17.01			17.25
15	18.96			18.66
16	17.11			17.33
17	14.93			14.59
18	12.67	12.79	12.79	12.71
19	21.05	21.20	21.26	20.91
20	78.76			78.20
21	57.99	58.23	58.31	58.90
22	102.36			100.14

*(Vide Right Side).

indices, especially noticeable in the pilasteric index. This would indicate that the right bone is slightly more compressed from side to side than is the left, particularly in the middle of the shaft. As just noted, our series of 100, shows larger indices and consequently a relatively greater sagittal diameters, than the other two series. The differences in index 8, indicate that in Grossberg's cases the femoral shaft is slightly more tapering from above downwards. Both our series agree in making the right bone slightly more tapering than the left.

We shall take occasion later to consider the lower half of the femoral shaft, refraining from any comparisons at present since our lower transverse diameter measurement, No. 13, is very different from Pearson's popliteal width.

With Pearson's indices we shall be as brief as possible. His right and left bone exhibit essentially the same features as outlined above for our material, the main exception being that his right bone, as compared with the left, is even more compressed laterally than is ours. Instead of comparing each individual index, we shall simply call attention to the more important differences between his material and ours as seen from the standpoint of indices. A number of these points have already been indicated in our discussion of the mean measurements. It will not be necessary to quote the absolute values of these indices, for this reference may be made to the tables.

Pearson's bones show higher indices in the platymeric and pilasteric regions than do ours, his material is characterized by a somewhat more gracile and slender shaft, due chiefly to smaller transverse dimensions. The index of upper gracility would indicate that his right bones are less tapering than ours, on the left this difference is not as marked. For shaft characters, irrespective of their relation to the length of the bone, the results show a greater similarity between the left bones of the two series than between the right. A number of indices involving the long shaft, or combined measurements, show higher, or sometimes lower values, due essentially to the shorter bones, which make up Pearson's series. They do not need to be considered in detail. However, his capito-collar length is distinctly longer than ours, as evidenced by all five of his capito-collar indices, Nos. 5, 6, 7, 14 and 16. The discrepancy is especially marked in 7, the third captio-collar index, known also as the epiphyseal ratio, due in this instance to the lower value of Pearson's bicondylar width.

His epiphyses, which were quite at variance with ours as regards their mean measurements, show also important indicial features. The head is smaller, even in terms of a shorter oblique length, index No. 19; smaller as compared with the bicondylar width, No. 21. The primary capital index, or the ellipticity of the head No. 4, is smaller than ours, indicating a less spherical head, or more elliptical on account of the greater antero-posterior flattening. The lower epiphysis, kneejoint, is, also smaller than in our material, indices 3, (7), 15 and 17. The lateral condyle is shorter, 17, relative to the trochanteric length, shorter also when compared with the bicondylar breadth, 20, and again even shorter in terms of the medial condyle, 22.

TABLE VIII
Comparison of Mean Index and Index of Means

Index	Mean Index	Index of Means	Difference	Range Max.	Range Min.
Platymeric Right................	84.39	83.54	.85	111.11	66.66
Platymeric Left.................	84.03	83.50	.53	111.53	66.25
Pilasteric Right................	104.43	104.12	.31	130.73	83.33
Pilasteric Left.................	103.21	102.87	.34	140.74	77.77

Right Platymeric Index

	Mean Index	Standard Deviation	Coefficient of Variability
100 Series..........................	84.387	8.871	10.511
Pearson (236).......................	85.326	8.765	10.272

All this bears out what we have said before concerning the small joints in Pearson's material, particularly the knee joint.

Parson's Rothwell bones were very platymeric, low indices, 77 on the right, 81 on the left. His modern English, very few in number, give very much higher figures, 83 on the right and 86 on the left.

The femoral indices given by Hrdlička for white males differ but very little from ours. His pilasteric formula however, trans. x 100/ sag, is the reverse of ours (q. v.). According to the above formula our pilasteric index for the right side would be 96.04, for the left 97.2; Hrdlička's are 96.3 and 97.4 respectively. His male white femora are consequently very slightly less compressed, from side to side in the middle of the shaft, than ours, while both series make this narrowing of the shaft more marked in the right bone. This difference between right and left is much more marked in the Munsees, while it is apparently absent in blacks. The platymeric indices in Hrdlička's whites deviate from ours somewhat more than do the pilasteric. His right and left indices are 82.8 and 84.1 as compared with our 83.54 and 83.50. His distinction between the two sides is much greater than ours, his right bone being much more flattened than the left. In our series there is but very little difference the left bone being a trifle flatter. In this respect our results agree with his Munsee and black material.

Taking the mean index, instead of the index of means, only accentuates the difference in the platymeric regions in our right and left bones (cf. Table VIII).

Hebburn gives a mean platymeric index 81.8, which Pearson corrects to 84.6, and a pilasteric index of 109.3 for 43 modern British femora, sex and side not noted. These indices stamp his femora as having a relatively greater anteroposterior dimension than ours.

We take it that the indices of Schwerz are based upon Martin's method, like Grossberg's, but this is not stated. The length of his Alamannen femora is distinctly greater than ours and with quite divergent shaft characters. His platymeric index, 80.5, is much lower than ours, i. e. the platymeric region is relatively broad. The pilastering is much more marked, on the other hand, as indicated by his higher pilasteric index. Both indices refer to male bones but without distinction as to side.

STATURE

There is but little data available on this subject but it may be presented for what it is worth. In thirteen of the 100 series the statue was given in the cadaver records. The determination had been made by Doctor Todd in the following manner. The body was suspended by the head, with the heels together and the soles flat on the floor. The lower limbs were almost if not completely extended. The figures which we shall note as stature are, therefore, rather too low than too high, and are somewhat different also from what Pearson (1899) has termed corpse length.

The mean stature, determined in the manner just mentioned for thirteen cases, was 1721 mm., the mean oblique length of the corresponding right femora is 456 mm. Both these means include a very large individual whose femora could not, for any good reasons, have been excluded from our series. The oblique length of the right femur in this case is 535, the stature was 1887 mm. If we deduct this one case, in view of the very small number involved, the mean femoral length of the remaining 12 is 450, the mean stature falling to 1708 mm. This new mean for stature is pratically identical with the mean stature of a very much larger number of male white adults, also dissecting room material.

Our results may be summarized briefly as follows. Using Pearson's formula, for living stature from dry bone and oblique femoral length,

$S = 81.232 + 1.894\ F_0$, we find that the resulting, calculated stature is, with one exception, too low. The case in question shows a femoral length of 418 mm., much below our average. The recorded stature was 1581, the lowest in the series. Pearson's formula gave the stature as 1602, an excess of 21 mm. This excess is undoubtedly too great since our statures are, if anything, low. We may note in passing that another femur, 12 mm., shorter, came from a body whose stature was 18 mm. greater.

For the remaining twelve cases the statures, as determined by Pearson's formula, fall short of the recorded figure by amounts varying from 16 to 105 mm., the mean being about 53 mm. Including the one case where the formula gave a high value, the mean discrepancy is reduced to 47 mm. If we include this case but exclude the 535 mm. femur noted above, the mean error of Pearson's formula is reduced again to 45 mm. This very long bone gave by the formula a stature too low by 64 mm. while a number of much shorter bones showed greater deviations from the stature as measured.

Manouvrier's data (l. c. 1893, Table II), give substantially the same results but they are slightly closer to the actual stature than are Pearson's. The mean deviation of —47 on Pearson's formula (v. s.) is by Manouvrier's method reduced to —40mm, the —45 (v. s.) to —36mm. The one case in which the formula gave too great a stature it is even greater on Manouvrier's data, +32 against +21. For the long femur which falls outside of Manouvrier's table we have used one of his "coefficients moyens ultimes," multiplying the femoral length by 3. 92. The result gave the recorded stature within one mm., 1888 instead of 1887.

In general both methods of estimating stature gave too low values, Manouvrier's being slightly more accurate for the individual cases in question and also for the means. In only two cases does Pearson's formula give closer results, one of these is the case where the result is too high while the other concerns the smallest bone of the series. It may be noted in addition that, while there is apparently no relation between the length of the femora and the accuracy of the calculated results, there is a relation between the latter and the recorded stature. Quite consistently, and by both methods, the absolute deviation from the real stature, increases progressively as the stature increases. In other words, both methods give better results when the stature is below our average, 1721 mm. One reason for this is that both Manouvrier and Pearson were dealing with smaller, shorter individuals.

While some deviation between the actual and calculated stature is naturally unavoidable, the deviations which we have encountered are too consistent, and many of them too great, to be passed without some comment. It is evident that our material is different from that upon which Manouvrier and Pearson have worked out their formulae and constants. Although our femora are absolutely much longer, they constitute, nevertheless, a smaller fraction of the standing height. There may be, then, either more body above or more limb below in order to make up the actual stature. As regards the former we have at present no evidence. Concerning the tibia, however, what data we have seems to indicate that the leg in our bodies may be relatively longer as compared with the thigh. Grossberg found a tibio-femoral index of 81.5 on the right side, Rollet's measurements would give an index of 80.8. Rollet's femora, for his larger statures which are more comparable with ours, make up 27.2% of the stature, in our 13 cases this percentage if 26.7 for the oblique length, removal of the longest bone further reduces this to 26.3%. The methods of Pearson and Manourier indicate that their oblique femoral lengths made up respectively 27.4% and 27.3% of the stature. Their material as well as Rollet's is very similar in this respect. For ours, however, a modification of the method would be necessary, although inclusion of the tibial length in the formula might give better results.

Hrdlička's whites appear to have a tibio-femoral relation more like ours. His index of 82 being even higher than ours, the tibiae Ering relatively a little longer.

AGE

Adequate treatment of this phase of our subject would require a much more extensive series of bones than those which we have been considering. We are concerned, at present, only with measureable quantities, dimensions. Other and finer features, more or less comparable with those which Todd (1920) has worked out so carefully for the symphysis, may very well be present in the femur, but they do not figure in the present discussion.

There are two reasons why the subject of age may not be inappropriate here. In the first place the age of the material is known, while in the second place the findings seemed to merit some attention. As regards age we shall naturally rely on our largest series, the numbers of bones involved may be seen from Table IV and V. We have investigated only the right side in this connection and shall say very little about the left side as such. Since the number of bones varies considerably for different measurements in the series of all bones, with which we are dealing, we shall not attempt to indicate the number for different ages and different measurements. Suffice it to say that under 21 years and beyond 50 years the amount of material becomes rather meager. Had we originally expected to touch upon the question of age, some of these deficiences might have been avoided, to some extent at least.

The age data to be presented here is based in part upon the mean values of five year intervals and in part upon the plotting of various characters in order of age.

In general there seems to be a very slight, but still appreciable tendency for higher values with advancing age, beginning somewhere under 25 and terminating between 45 and 50. The youngest bones show values above and below the mean age values, varying considerably for different characters. Those over 50 are also somewhat erratic, more consistent however than the youngest ones, but the numbers are again too small to support any conclusions. As far as they go, these older cases would give evidence or retrograde changes in the femur, i. e., a slight decrease in its general proportions. Within the age limits first mentioned the behavior of the several characters is essentially the same. Between the early thirties and late forties where our material is most abundant, the gradual increase in values is most consistent. In any case it is very small and closely related characters are not always affected in the same way.

The best example found is the epicondylar breadth, a close second, but rising somewhat more rapidly, is the width of the inferior articular surface. The projected lengths of the condyles, especially the medial, fluctuate so much that any upward trend which might be present is almost entirely obscured. The epiphyseal height behaves much like the articular width but the increase comes on later, is more abrupt, and also continues longer. The head of the femur does not show as much increase as the lower end, what there is affecting the vertical rather than the horizontal. As regards the diaphysis, the pilasteric transverse rises more definitely than any other character, any increase in the sagittal diameter is slight and occurs late. The sagittal diameter at the lower end, measurement No. 12, shows at best the height of its rise between 36 and 40 years, while No. 13, transversally at the same level, is the only character which shows a uniform fall, dropping steadily from between 26 and 30 to between 41 and 45. The oblique and trochanter lengths naturally run parallel, increasing steadily from the early thirties to the late forties, gaining about a half inch during this period.

We have been sceptical about this increase in femoral length with age, although for the decade from 31 to 40. there are more than a hundred specimens, and this increase is continued for the oblique length for another 10 years, but the evidence rests upon very much smaller numbers. The other femoral characters naturally show smaller differences, but their behavior leads us to put much more confidence in them than in the long measurements.

The general trend of some of our measurements, arranged in order of age, leaves one with the impression that during a certain period, roughly during the thirties, certain femoral characters are relatively constant and quiescent, while earlier and later they are subject to greater fluctuations. This may of course be due merely to chance sampling, or it might be comparable to the relatively quiescent phases of pubic metamorphosis (Todd). It is as if the bone settled down, as it were, for a short period with nothing to disturb it.

There is also another angle of the subject of age. At a certain stage of the work it was easy to determine the number of bones which were above or below the mean for each character and the relation of this deviation to age. Briefly, and to mention only one feature, there was a very consistent clumping in certain years of those absolute measurements which were greater than the mean and which exceeded, numerically, those cases which were less than the mean. For different femoral characters and for different ages there might be more bones above the mean or there might be more below. In the ten years for 36 to 45, however, the thirteen characters examined showed, almost without exception, that the larger bones were more numerous than the smaller ones. The horizontal diameter of the head was the only noteworthy exception. In the cases of younger and older bones the numerical excess might fall either in favor of large or of small bones, and this quite independently of the other characters. All this indicates that our material, right side, is largest around the age of 40 years. Our series of 100 right bones gives identical results. For femoral lengths we are by no means convinced that our material is adequate, but for other features we believe that the evidence is more trustworthy.

We do not believe that the findings have been influenced materially by any lipping of the articular surfaces.

Powys (1901) found that the maximum stature has attained at about

28 years in the male and 25 years in the female. After these ages he noted a slow but steady decline.

SUMMARY

In summarizing briefly the results of our observations on the femora of male whites, we would remind the reader that the conclusions depend upon a large number of small points, upon a segregation of various characters, rather than upon any striking or isolated absolute values. We are aware, also, that we are offering evidence rather than proof. The character of the material used can, however, only strengthen this evidence, even if it still falls short of being an actual demonstration.

As regards the variability of the femur as a whole, the differences between the right and left sides are very small. Nevertheless, the right bone appears to be slightly more constant. Irrespective of side, however, the epiphyses represent the most constant part of the bone, the diaphysis the most variable.

In terms of absolute dimensions, the epiphyses on the right side are larger than those on the left, for the diaphysis the relations are reversed. This accounts for the slightly greater bulk, and length, of the left femur. There are also a number of minor differences in the mean proportions of the right and left bones.

We have intentionally avoided any allusions to race, and as far as comparisons have been made or seemed at all permissible, they indicate that we have been dealing with relatively large bones. This greater size is most noticeable in the joint ends, particularly in the knee joint, although we are inclined to believe that the comparison should be reversed to the effect that certain other series of femora have shown very small articular ends.

A gradual increase in the general proportions of the femur with age seems to be present. It is probably very small, affecting different characters in different ways, but our series is unfitted to throw light upon this question.

Although the mean length of our femora is relatively high, it contributes less to the standing height than do Pearson's or Manouvrier's. Our material shows relatively short thighs, different body proportions, the balance being restored, apparently by somewhat larger legs, or possibly by a longer trunk as well.

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THE "CERVICAL FOSSA" OF ALLEN

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In his description of the neck of the femur Allen '82 stated that it "is marked in front near the articular surface by a faint depression, which is often cribiform in appearance and may receive the name cervical fossa." Allen made no further comment upon this fossa which seems to have remained unnoticed until Bertaux '91 called attention to it in an extensive study upon the humerus and femur. Bertaux regarded this imprint as he called it, as the place of insertion of a "fort trousseau de la capsule articularie." He did not describe the capsular fasciculus supposed to be responsible for the imprint, but it would seem that he had one of the so-called retinacula in mind, such as illustrated in Fig. 1. But even when they are very strong and numerous, these structure, even when located as would be necessary, manifestly can not produce the facet in question. Poirier '11 also wrote that he searched in vain for a capsular fasciculus responsible for the impression of Bertaux and wrongly stated that the facet had up to then (1911) escaped the attention of anatomists.

Sudeck '99 likewise failed to find the cervical fossa of Allen described in anatomical texts, but called attention to the fact that a ridge is indicated in an illustration of the femur by Henle '67. Scrutiny of the illustration concerned in Henle, Fig. 244, 1855 and Fig. 243, 1867 and 1871 confirms Sudeck's statement. But as the latter emphasized, no mention of this surface marking was made by Henle in the accompanying text. Hence one is left to surmise regarding the interpretation of the figures in question and as to Henle's conception of the facet for the drawings indicate only a slight ridge near the region of Allen's cervical fossa. Cruveilhier '62 also represented the ridge shown in the illustration from Henle '55 but since his Fig. 197 and Figs. 198–201 inclusive are identical with Figs. 244, 245, 248, 246, and 249 of Henle, and since the third edition of Cruveilhier '51 does not contain them or any comment upon this ridge the credit very clearly belongs to Henle.

Fick '04 stated that Henke also knew the region in question as an extension of the articular cartilage, but Fick seems to have regarded

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the imprint of Bertaux as identical with the Halsgelenkhöcker (Emenentia articularis colli femoris m.) of himself, Henke and others.

Poirier described the facet in question by saying that "En haut et en dedans, vers la tête, la face antérieure du col offre une surface rugueuse à laquella j'ai donnè le nom *d'empreinte iliaque*, parce qu'elle me paraît résulter de la pression exercée en ce point par le bord antérieur de l'os iliaque dans la position assise ou accroupie."

Testüt '11 also referred to this landmark in his descriptions of the neck of the femur saying "The anterior face of the neck of the femur often presents a small rough oval surface with ill-defined contour, close to the head. This facet to which Bertaux called attention in a thesis in 1891 is covered by a layer of cartilage in the fresh state." Testüt further said that its relation to the head is variable, sometimes being separated from it by a narrow zone devoid of cartilage, but that at other times it is continuous with the head without any line of demarcation, adding that "Its morphological value does not seem to me to be clearly elucidated."

Sudeck regarded the imprint of Bertaux as constantly present although he said that it varied greatly in conspicuousness. But Parsons '13–'14 found it present in only 79 per cent of male femurs regardless of right or left. He found it present in 67 per cent of the left and in 58 per cent of right female femurs. Parsons believed that the facet is just as often present in modern as in pre-historic bones, basing his opinion upon 400 fourteenth, fifteenth and sixteenth century, midland, English femurs the sex of which was determined arbitrarily.

Walmsley '15, who also described this facet further called attention to a hitherto undescribed bony ridge which divides the anterior surface of the femoral neck into an outer smooth and an inner rough surface. It apparently is this ridge that is indicated by Henle and Cruveilhier. Walmsley found this ridge "absolutely constant in position in all adult bones, though it varies within wide limits as regards its degree of evidence." It unfortunately was not stated, however, how large a series of femurs was examined. Walmsley added that "It is thus early to be insisted on that this ridge is not merely the external limit of the medial rough area; but represents the internal boundary of and belongs to the lateral smooth area. The whole evidence of its causation demonstrates this fact." It would seem that Walmsley, like Fick, regarded the cervical fossa of Allen and the imprint of Bertaux, Testit, Poirier and Parsons as equivalent to the eminentia articularis colli femoris of Fick for he stated that the anterior excursions of the articular

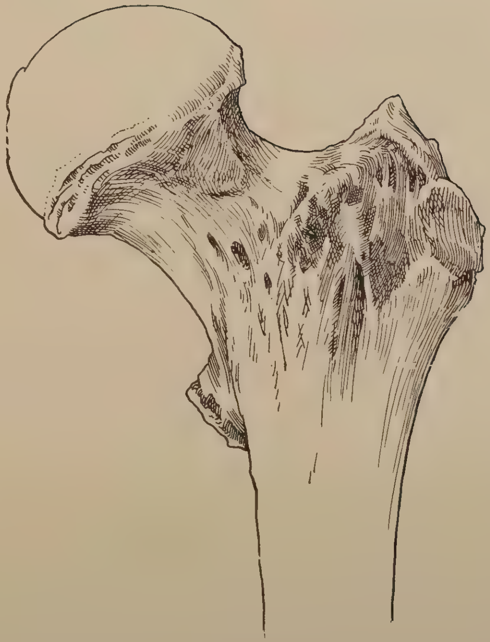

Fig. 1
Numerous strong retentaculae capsularis

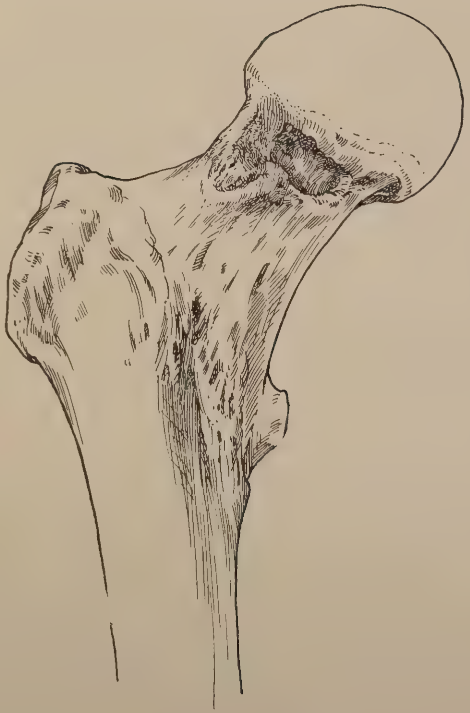

Fig. 3
A form of anterior acetabular imprint

surface of the femoral head, such as represented in Fig. 2, simply are "varitions of the more commonly found roughenings."

Walmsley never found this extension of the articular surface upon the neck to have an absolutely smooth surface. He did not find it in young subjects but always found it associated with "strong, bony, ligamentous markings and with powerful capsular bands." Walmsley further stated that the excursion of the articular surface of the head never is "in physiological continuity with the articular surface from which it springs, being curved in one direction only, anteroposteriorly, but perfectly flat in the lateromedial plane." This conception is contrary to fact, however, as shown by such specimens as represented in Fig. 2.

Walmsley found the medial rough area in three conditions: "rough in about 70 per cent, almost smooth in about 20 per cent, and in the remaining 10 more or less cartilage-covered." But he did not state the extent of the series concerned and since Walmsley apparently drew these conclusions from fresh material it is impossible to know whether the second group of 20 per cent in which this medial rough area was "almost smooth" would have been found in this condition when devoid of soft parts. If so, then there really would seem to have been no special rough area at all, for I think all will agree that no considerable portion of the femoral neck is ever found more than "almost smooth" for although polishing is relatively common in other bones of the skeleton, I have never seen it on the neck of the normal femur.

My own observations upon dissecting room material and upon cleaned bones confirm the results as to frequency obtained by Parsons very well. It must be remembered, however that exact correspondence between the results obtained by two investigators can not be expected, because it always will remain a matter of opinion whether the cervical fossa of Allen or the imprint of Bertaux is present in a considerable portion of the femurs. Indeed, the imprint of Bertaux is much more variable in character than heretofore indicated. It varies from the slightest increase in roughening over a smooth, ill-defined area to a large, deep incision several centimeters in length and extending roughly parallel to the articular surface of the head of the femur. This is illustrated very well in Figs. 3–7 inclusive.

A ridge such as presented by Crüveilhier and Henle, the significance of which Sudeck especially discussed and which Walmsley designated as the capsular ridge, may or may not be present. It infrequently is prominent in cases in which the iliac imprint is only a slightly roughened area and may be absent altogether when marked roughening is present. Except for this ridge which, when present, bounds the rough surface laterally, the area forming the imprint of Bertaux usually is depressed below the level of the surrounding neck. Hence Allen's suggestion of cervical fossa is especially applicable. It seldom is raised above the surrounding surface. Hence it is incorrect to regard the imprint merely as an eminence even if the eminentia articularis colli femoris can rightly be regarded as part of it. When well-defined this extension of the articular surface of the head upon the neck usually has the exact character of the rest of the articular surface of the femoral head. Such not infrequently is the case even when, as shown in Fig. 2, it extends far out upon the neck of the femur.

As shown in Fig. 7, the cervical fossa of Allen may be deep and rarely forms an incision, accompanied or unaccompanied by a lateral roughened area or ridge. When elevated above the rest of the femoral neck, as rarely is the case, this imprint may not be sharply delimited from the articular surface on the head of the femur but it is only rarely that I have found such transition forms as those shown in Figs. 8 and 9. Moreover, my own observations confirm the statement of Poirier that whenever marked excursions of the articular surface of the head upon the neck are present in this area the imprint is absent. This, it seems to me, is of great significance although it does not therefore follow that Walmsley is mistaken in concluding that the eminentia articularis colli femoris of Fick and the imprint of Bertaux are functionally related.

Although the area of the imprint varies greatly in extent and also in the nature of its surface, I never have seen any evidences of polishing on it. It varies somewhat in circumferential position and may extend dorsally a little beyond a frontal plane passing between the anterior one-third and posterior two-thirds of the neck of the femur. Inferiorly it may reach the same plane but it also may be confined to a very small but nevertheless very definite area, located wholly upon the anterior surface of the femoral neck as shown in Fig. 3. The exact shape of the area laterally, is largely determined by the shape of the neck of the femur. Moreover, it is evident that whenever the anterior surface of the neck lies almost in the same plane as the lateral portion of the articular surface of the head of the femur, the demarcation between the two is ill-defined. On the other hand, whenever the difference in level between these surfaces is marked the area is well-defined and gradual transitions between it and the articular surface of the head are then absent. However, three fine specimens of eminentia articularis colli

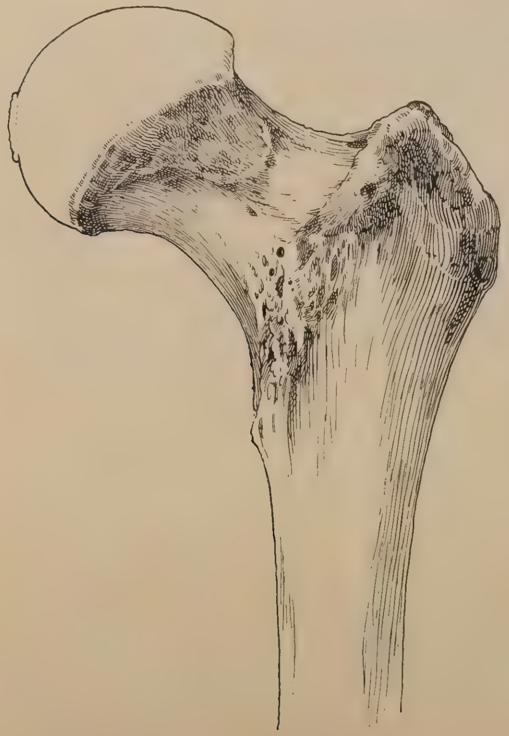

FIG. 4

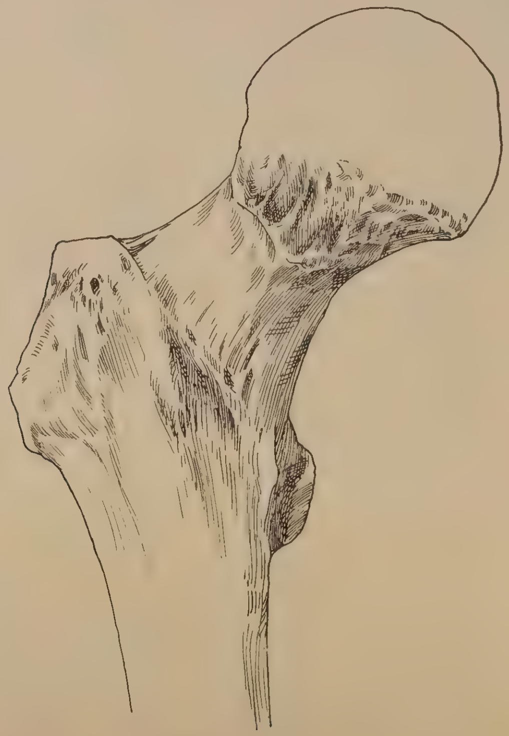

FIG. 5

Different forms of anterior acetabular imprint

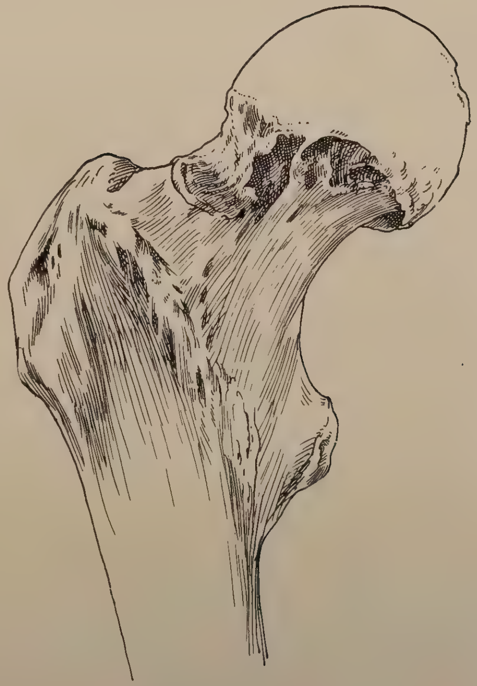

FIG. 6

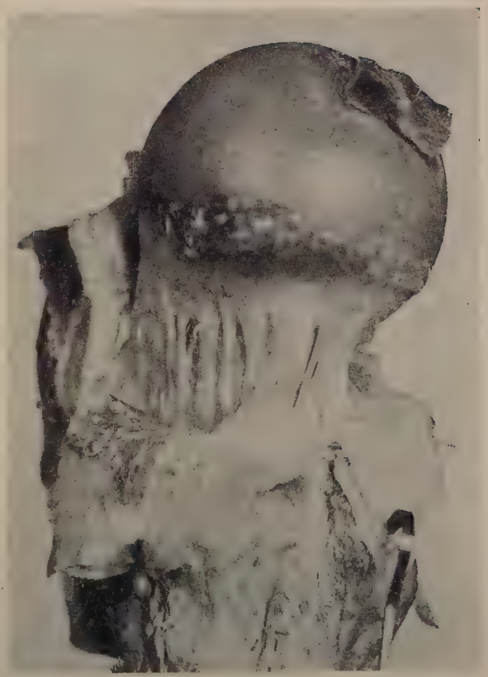

FIG. 7—172, R. Femur.

Different forms of anterior acetabular imprint

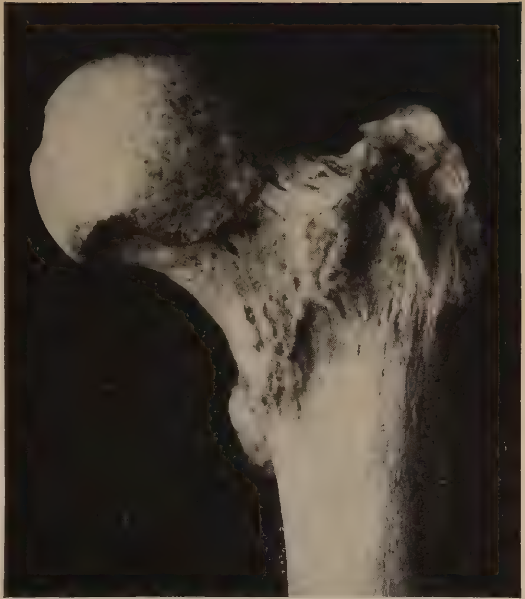

FIG. 2

A large eminentia articularis colli femoris

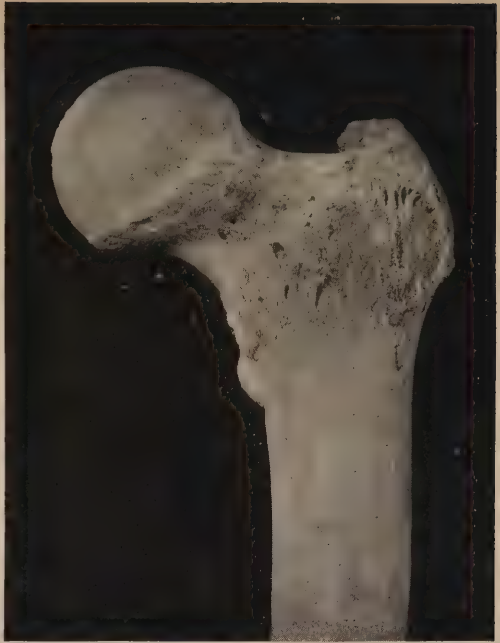

FIG. 8

A transitional form of eminentia articularis colli femoris

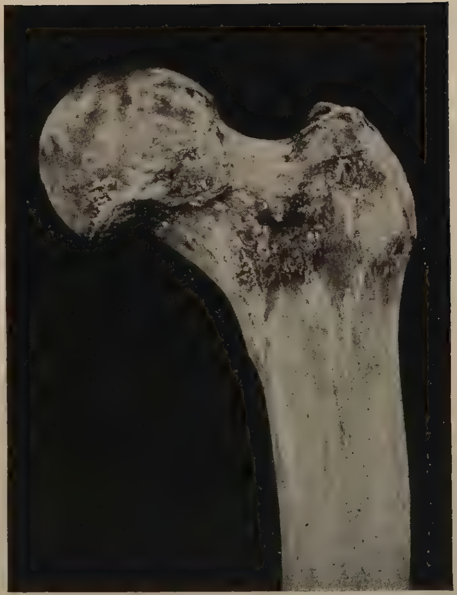

Fig. 9

A transitional form of fossa articularis colli femoris

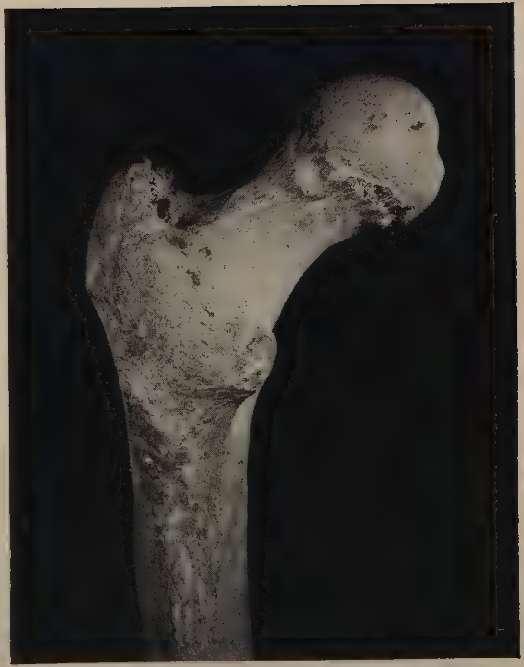

Fig. 10

Posterior acetabular imprint

femoris in my possession are definitely delimited in spite of the fact that there is no marked difference in level between the anterior surface of the neck of the femur and the articular surface of the head. It is these and similar areas that are cartilage covered and form an integral part of the articular surface of the head of the femur.

I have no tabulated series regarding the presence of cartilage upon the imprints of Bertaux but observations made during several years upon dissecting room material, leave me with the impression that it was present in somewhat less than 10 per cent of the cases, as reported by Walmsley. However, since Walmsley included the eminentia articularis colli femoris among the imprints of Bertaux he would naturally have a higher estimate. Not infrequently the cartilage upon the imprint of Bertaux is fibrous rather than hyaline, while that on such eminentiae articularis colli femores, as represented in Fig. 7 always is truly hyaline and directly continuous with the cartilage upon the head of the femur.

Since the capsular ridge of Walmsley, when present, is an integral part of the imprint of Bertaux, there would seem to be no good reason for considering it alone or for giving it a separate designation. This, however, does not apply to the eminentia articularis colli femoris. This may well, and no doubt does, prevent the cervical fossa from forming but this does not imply that the two necessarily are identical. Hence for the present at least, it seems preferable to retain a separate name for this extension of the articular surface of the head upon the anterior superior region of the neck of the femur.

My own observations included femurs the sex, nationality or age of many of which unfortunately were unknown. However, most of them were Caucasian—American and European—, a few Chinese and Japanese and a small number were Mexican and American Indian; both pure and crossed. Among these 449 femurs the imprint of Bertaux was present in 70.6 per cent. It was found in 71.6 per cent of the right and 60.9 per cent of the left femurs. The imprint was present in all these races, thus confirming the observations of Parsons. An anterior incision was present in only 3 among 163 femurs. An anterior extension of the articular surface, i. e. an eminentia articularis colli femoris (Fick); was present in 4, and a posterior extension in only 1 among 81 right femurs. In 82 left femurs there were 3 anterior and 1 posterior extensions. A posterior roughening, i. e. a posterior acetabular imprint, was present in 3 left and in 2 right femurs among these groups.

It is of considerable interest in connection with these imprints that among 144 medical students, the large majority preferred to rest on the right side. A somewhat smaller number preferred the left and about one-third had no preference for either side. Among the latter the larger number preferred the prone posture and a very small number the supine. Although no exact correspondence was found to exist between the results of such an inquiry as this and the observations made on bones, the agreement is nevertheless very striking. Nor should one expect an exact correspondence unless one had identical groups for it is undoubtedly true that preference for one posture or the other becomes increasingly pronounced with the advance in years.

Only the slightest indications of it were present in femurs from the second and third decades. This also agrees with the observations of Parsons but since the number of these femurs was small I do not feel justified in emphasizing this finding. However, it is my impression that the imprint of Bertaux is more pronounced in advanced years and that no indication whatever of it is present in fetal and infantile femurs. This is contrary to the statement of Sudeck who believed that it was due to late ossification in a plate of cartilage found in this area in fetal and infantile bones and that the ridge was related to the inner architecture of the neck. The imprint may be very shallow in very pronouncedly senile skeletons and hence can not be regarded as an inevitable by-product of years alone.

As stated above, Bertaux thought that it marked the attachment of a strong capsular fasciculus. Poirier, who added the adjective iliac to the word imprint, believed that it was effected by pressure of the osseous acetabular rim upon this area in the sitting or squatting posture. But in these postures the femurs are rotated outward, and as Fick and Parsons emphasized, contact between the assumed opposed surfaces in these positions requires abduction and marked medial rotation of the lower extremity. Moreover, since the facet in question is just as common in modern as in pre-historic men, squatting would seem to be excluded as a factor in its production by this fact alone as Parsons emphasized. That contact of the respective surfaces does not occur in the customary sitting and squatting postures can easily be demonstrated. Walmsley too was convinced of this, but reached the conclusion that the rough area or imprint of Bertaux "represents the amount of contact of this portion of the neck of the femur with the vertical limb of the ilio-femoral ligament in the position of complete extension" of the lower extremity. This explanation is especially interesting in view of the fact that Walmsley concluded that the "capsular groove" upon the lateral smooth area of the neck is due to tension of the "supero-lateral part of the anterior capsule" in the same position of the limb. Walmsley added that in this position "this part of the capsule acts in such a spiral manner" as to produce it.

It is difficult to see how tension during motion, upon one portion of the capsule produces a smooth area, and tension during the same motion upon a different but contiguous portion of the same capsule, causes roughening upon an adjacent area. Such wholly diverse results surely should not result from the same cause acting upon the same structures. This explanation also leaves the capsular ridge wholly unaccounted for. Walmsley merely says that there is a close relation between the capsular development and the "degree of evidence of the capsular ridge and the marking off of the capsular groove." Since the latter as is well known is produced by pressure of the orbicular fibers of the joint capsule, no one will doubt that its presence is related to capsular development. However, since a plainly evident groove is seldom present upon the superior surface of the femoral neck and practically never upon the inferior surface, it is very likely that it is more a question of the correlation in size between the capsule and the calibre of the neck of the femur than a matter of strength of capsule. I can not recall a single specimen in our collection in which an intermittent moving pressure from a muscle tendon or ligament produced a roughening of the underlying bony surface. Tendon grooves illustrate a moulding and smoothing effect of moving pressures from soft parts upon bones and movable *bony* contacts when prolonged, result in polishing.

The fact that the imprint of Bertaux very often is represented by a rough fossa or even by a deep incision with rough irregular walls, such as is shown in Fig. 7, makes it very unlikely that intermittent movable contact with any constituent of the joint capsule produces it. That the anterior ilio-femoral ligament can not produce this rough elevation, fossa or incision, is suggested also by the fact that the main direction of the imprint does not lie in the line that such an explanation would require. The ilio-femoral ligament usually makes an angle of about 15 degrees with the prevailing direction of the imprint.

As far as I am aware only two sulci are known to occur upon the neck of the femur. Both are inconstant in occurrence although constant in position. One of these is the sulcus produced upon the dorsum of the femoral neck by the tendon of the obturator externus and the other is that due to the orbicular constituent of the joint capsule. It apparently is the latter which Walmsley designated as the capsular groove. The presence of an occasional sulcus due to the tendon of the obturator externus is proof of the fact that great pressures are not necessary for the production of impressions upon bones, for this groove must of necessity be produced by pressure from a tendon running mainly parallel to the neck of the femur and acting through the intervening joint capsule.

It is always a little venturesome, I presume, to use a designation with functional implications. Yet I like the term Iliac Imprint suggested by Poirier. For in spite of the very crucial objections raised by Fick, Parsons and Walmsley to Poirier's idea of the posture in which this imprint is produced and in which I heartily concur, I see no reason why such contacts could not produce the assumed effect. However, no one except Poirier adopted such an explanation, yet I firmly believe that pressure contact is responsible for the facet in question, and that it hence really is an acetabular imprint. But I do not believe that either intermittent movement or pressure from a portion of the joint capsule in walking is responsible. The nature of the facet alone is proof of this.

Many undoubted illustrations could be given to show that direct bony pressures are unnecessary to produce absorption areas in bone. Just as pressure from the tendon of the obturator externus produces a sulcus upon the dorsum of the neck of the femur in spite of the interposition of the articular capsule and the synovial membranes and periosteum, so indirect bony pressures can produce even more pronounced effects. Nor do such bony pressures need to be large. An important consideration is the fact that areas subjected to them always are rough and not polished. Movement of bones alone can polish an area; bony pressure alone cannot do so.

Not infrequently the iliac imprint is bordered laterally by an osseous ridge apparently due to periosteal irritation and reaction. The particular effect produced upon the periosteum, no doubt depends largely upon the age and the peculiarity in reaction in the individual and less upon the nature of the pressure.

All the variations in the nature of the iliac imprint known to me could, I believe, result from pressure of the ligamentous acetabular lip alone. Direct contact between the osseous lip and the portion of the neck in question is not necessary and frequently also not possible, at least not in laboratory material. However, since this material is fixed it is not a reliable guide to what is possible during life when the joint capsule is so much more yielding, or under conditions of capsular relaxation.

The only posture in which contact of the affected area upon the femoral neck and any area of the ligamentous lip would seem to be possible, is that of lying upon the side. Aside from the use of the upper extremity, this posture is maintained in sleep by partial flexion of one or both thighs upon the abdomen and some check at the hip joint is necessary to prevent rotation forward of the trunk upon the extremity in contact with the underlying surface. Such a check could be supplied in three ways: (1) by the external rotators at the hip, (2) by resistance upon the dorsal portion of the capsule of the hip joint and (3) by contact of the ligamentous acetabular lip with the neck of the femur. The external rotators at the hip can be excluded because they could not act during sleep. The dorsal portion of the joint capsule can be excluded because the ischio-femoral ligament becomes relaxed when the thigh is flexed and hence does not become taut early enough to prevent rotation forward. Moreover, since the reflection of the dorsal portion of the joint capsule upon the femoral neck is so relatively near the acetabular attachment, it could not act very efficiently and a little stretching of this portion of the capsule would permit considerable rotation of the trunk on the lower extremity to occur.

The only other possible check to rotaton of the trunk in this posture manifestly is contact between a portion of the anterior surface of the femoral neck and some portion of the acetabular lip. The exact place of contact between these two structures necessarily must vary with the degree of flexion of the thighs, the curvature and the calibre of the neck of the femur; especially as compared to the diameter of the femoral head; the depth of the acetabulum and the slope of its walls.

The range of flection of the thighs in the resting posture peculiar to the indiviudal will determine the length of the iliac imprint in a direction parallel to the periphery of the articular surface of the femoral head. The other factors mentioned can determine the width of the imprint in a direction parallel to the long axis of the neck. The height of the ligamentous and to a minor degree also the configurations of the osseous lip, probably determine the finer characteristics of the imprint. It commonly is possible to demonstrate a complete congruence between a portion of the surface of the iliac imprint and a portion of the osseous labrum glenoidale in laboratory specimens devoid of their soft parts. Yet it is only very rarely that the ligamentous acetabular lip is detached sufficiently to permit the necessary displacement of it thus making more direct contact of the affected osseous areas possible. Nor is such director contact necessary, for irregularities in the osseous acetabular lip can be reproduced in the region of the imprint because the osseous elevations upon the acetabular rim have a thinner ligamentous covering than the depressions.

The roughening of the imprint when the latter is raised above the surrounding surface can, it seems to me, be attributed to periosteal reaction and when depressed to unequal absorption. The latter gives rise to the commonest form of imprint which is a depression and for this reason no doubt suggested the term cervical fossa to Allen. It and the incisions rarely met with, both can be regarded as due to absorption from intermittent but relatively long-continued pressures such as could easily be and no doubt are, exerted during sleep.

The ridge frequently present immediately lateral to the iliac imprint, can be attributed to periosteal reaction in a zone of pressure insufficient to cause absorption but sufficient to cause irritation of the periosteum and deposition of bone. That absorption of bone often results from far more intermittent and smaller pressures is abundantly illustrated by evidences obtained in fractures and by such phenomena as that afforded by the supracondylar fossae reported by Meyer '24. It also is illustrated by absorption pressures due to pulsation of arteries and related phenomena. Under abnormal conditions such as arthritis, it is not very uncommon to find the newly deposited bone molded by the acetabular lip around a large part of the circumference of the femoral neck. Since very thin new deposits may contain a shallow, rounded groove it is evident that the acetabular lip and the femoral neck are not far apart under normal conditions.

The above explanation of the genesis of the iliac imprint accounts satisfactorily for its relative incidence on the two sides of the body, and also satisfactorily accounts for differences between opposite sides in the same body. From observations upon dissecting room material it is quite clear that differences in strength between the capsules on opposite sides of the same body can not account for these variations. Since most persons show a preference for lying on one side or the other, we have here a factor which easily can account for the differences observed on two sides of the same body. Differences in different bodies can be explained similarly. Moreover, since lying on the side always is a gradually acquired habit, and since one scarcely would expect absorption effects to manifest themselves during the period of greatest growth and vigor, young bones should not possess as definite an imprint as those from later years. This is in accordance with the facts for I never have seen iliac imprints before the third decade of life.

Very rarely I have also noticed a similar but smaller imprint upon the dorsal surface of the neck of the femur as represented in figure 10. This facet which in all probability is produced similarly but in a position of external rotation in the prone posture, is located directly dorsal to the cervical fossa of Allen. It too is represented by a shallow fossa with roughened surface and well might be called the ischial imprint. However Walmsley has used this designation for a narrow facet which skirts the articular margin of the femoral head directly above the location of the imprint here described. Hence I suggest the terms anterior and posterior acetabular imprints to designate the cervical fossa of Allen and the posterior imprint here reported.

Lateral rotation of the lower extremity in the prone posture could produce the posterior imprint just as anterior rotation while resting on the side could produce the anterior acetabular imprint. Since a small number of individuals occupy this posture by preference, during sleep, there is no difficulty in accepting such an explanation. It must be stated, however, that in most cadavers contact between the dorsal surface of the femoral neck and the ischial portion of the acetabular rim is prevented by the anterior portion of the articular capsule. Rarely, however, the shape of the acetabulum and also that of the femoral neck is such as to make this contact possible. It may also be that the anterior portion of the joint capsule becomes stretched in persons who habitaully occupy the prone posture during sleep thus making contact possible. I have not been able to examine a sufficiently large number of femurs possessing this imprint to ascertain the existence of other possible causative factors than the above. However, this imprint has the same character and also the same relation to the well-known lateral excursion of the articular surface of the head of the femur upon the dorsal surface of the neck as the anterior imprint. Since this dorsal excursion of the articular surface of the femoral head has received no special designation it would seem quite proper to suggest the name eminentia articularis colli femoris posterior.

It is possible that these extensions of the articular surface upon the neck of the femur can be regarded as a functional response in early infancy, to pressure exerted upon the respective regions by the acetabular lip. Nor is it necessary to assume, or very likely for that matter, that such pressure is due to bony contact in early life under normal conditions. If these extensions have such an origin they would, to be sure, be functionally related to the anterior and posterior acetabular imprints. In the one case it could be a protective response in early life; in the other, a loss of substance through absorption taking place largely or wholly after maturity is reached. The particular result achieved may be determined by the habits and also by the nature of the response evoked in the particular individual concerned.

Some support to this interpretation is afforded by the occurrence of anterior acetabular imprints which seem to be transition forms between some types of imprints and the eminentia articularis colli femoris (Fick). See Figs. 8 and 9. The presence of varying amounts of cartilage over the area of the anterior imprint in specimens in which considerable difference in level between it and the articular surface of the head of the femur exists, also suggests a functional response. Moreover, since the anterior acetabular imprint and true eminentiaea articularis colli femores never are associated, it is possible that the nature of the individual response is the determining factor. Although an extension of the articular surface of the head of the femur in response to use may at first thought seem impossible, a shifting of the articular surface in connection with the changed relationship of the apposed articular surfaces long has been known to occur in hallux valgus and similar conditions.

Although I have not made the pubic and ischial imprints of Walmsley the subject of extended investigations, I have, for some time, given special consideration to them and feel convinced that contact of a normal acetabular rim with these regions is impossible. As Walmsley's illustrations plainly show, the surfaces in question lie in a totally different plane than the periphery of the articular surface of the head of the femur. Indeed, not infrequently they make an angle of almost 90 degrees with it and usually lie considerably below its level. Since Walmslay found these imprints constantly present in the series of femurs examined by him, it would seem to follow that bony contact between these areas and the acetabular rim normally and constantly should occur in all individuals.

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PATELLAR SUPRACONDYLAR FOSSAE

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The human anatomist often comes upon evidences in the cadaver before which he must stand mute because experimental methods of approach are excluded and the history of the body unknown. Years or even decades of observation hence not infrequently are necessary to confirm or refute a conception which he may have formed regarding the occurrence of some character. The distal ends of the femurs shown in Figs. 1, 2 and 3 offer such evidence. In these specimens and also in one other which has recently come to my attention, a fossa is present in the anterior supracondylar region. In three of these femurs the fossa, which varies considerably in depth and size, looks as though it might have been made in a softened bone by pressure from the thumb. This is shown especially well in the drawings in Figs. 4 and 5. Hence these well might be called digital impressions although wholly unrelated to the impressions in the cranium known by that name. The occurrence of these fossae apparently is very rare for although the first two came to my attention over a decade ago I have observed only two other instances since. Moreover, I have been unable to find any mention of them in the literature of either normal or pathological anatomy.

The first two femurs are from the same female cadaver. The last two observed are from males. The femurs represented and the accompanying patellae are arthritic but the other is normal. At first thought it seemed quite probable that the fossae in question must have resulted in some way from pressure of the patellae or prehaps even from pressure from some device worn by the individual to increase the stability of or to give relief to the knee joints. However, some of the fossae seemed to lie a little too high and the patella from the femur with the deepest fossa had a wide, thin, irregular, osseous margin which gave very little evidence of having borne pressures sufficient to produce such a deep fossa. It was hardly recurved at all. Hence I felt unjustified to come to such a conclusion without further evidence. Very recently, however, such evidence was afforded by the femur and patella shown in Fig. 3. Both this femur and patella are arthritic and the lateral condyle of the femur and the lateral articular surface of the patella are deeply worn

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and exquisitely polished. A portion of the respective articular surfaces of these bones is not only polished but also worn into ridges and sulci which fit each other perfectly. The latter enables one to place this patella in the exact position which it occupied during life. If this is done and the patella brought forward and upward it easily glides into place so that a portion of the arthritic lip fits perfectly into the somewhat irregular sulcus located in the supracondylar region. As shown in the figure, the depression in question has two shallow fossae lying mainly in a transverse plane. A portion of the thin superior arthritic margin of the patella fits these depressions exactly. Moreover the lateral of the two fossae as well as the coapted portion of the arthritic patellar margin, is smoother than the medial.

Careful examination of the patella and the femur shown in Fig. 1 shows that the very wide arthritic margin of this patella also has two rounded portions. One of these fits into the large, deep medial supracondylar fossa and the other into the very small shallow lateral one not conspicuous in the photograph. Since this arthritic patellar lip and the markedly arthritic condylar surface of the femur also have polished facets, this patella also can be oriented very accurately. When this is done and the patella moved forward and upward it also slides into position into the supracondylar fossa. Moreover, the coaptation of the two surfaces is so perfect that it is very clear that nothing but actual contact between them could have shaped them. Because of these things I can no longer doubt that such supracondylar fossae as here described really are patellar in origin.

Although the surface of these supracondylar fossae is smoother in some portions than in others, no polishing is present. Nor would one expect this, for in the fresh state the fossae and the arthritic margins still were covered by soft parts. Hence it is clear that such fossae as these are not abrasion products for bony contact soon would result in polishing.

As far as I can learn the exact mechanism of pressure absorption is not known but I have seen fine examples of it upon the head of the first metatarsals in connection with hallux valgus and fractures. Moreover, it long has been known that relatively slight pressures from tumors, for example, are sufficient to produce absorption effects provided they act long enough.

It is difficult to see how pressure from muscle tension could be exerted upon the patella in the given position, and it is well to bear in mind that this pressure must be exerted through the articularis genu when

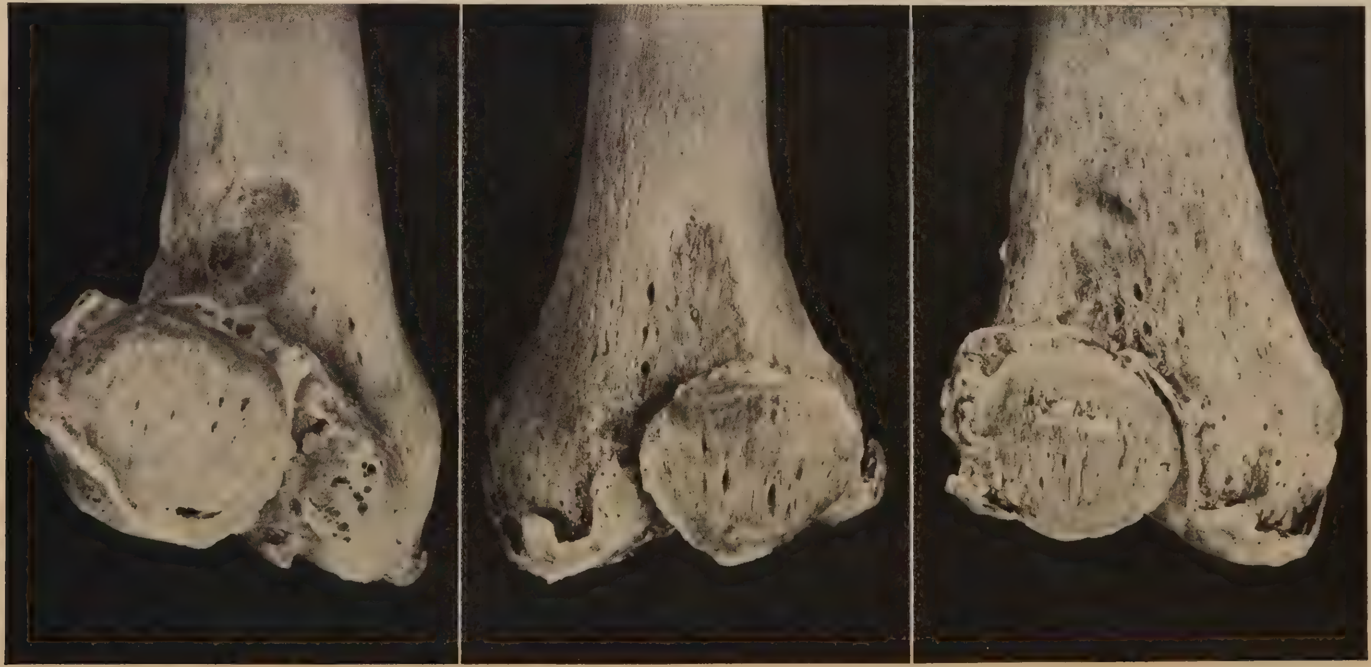

Fig. 1 Fig. 2 Fig. 3

Photographs of supracondylar patellar fossae in arthritic femurs.
Figures 1 and 2 represent paired bones.

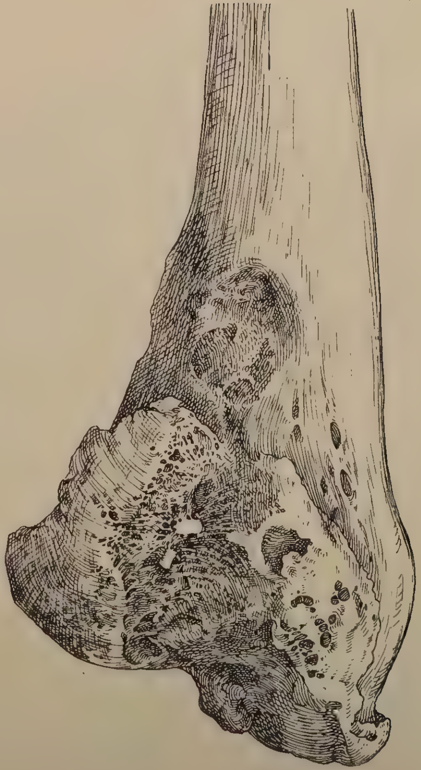

FIG. 4

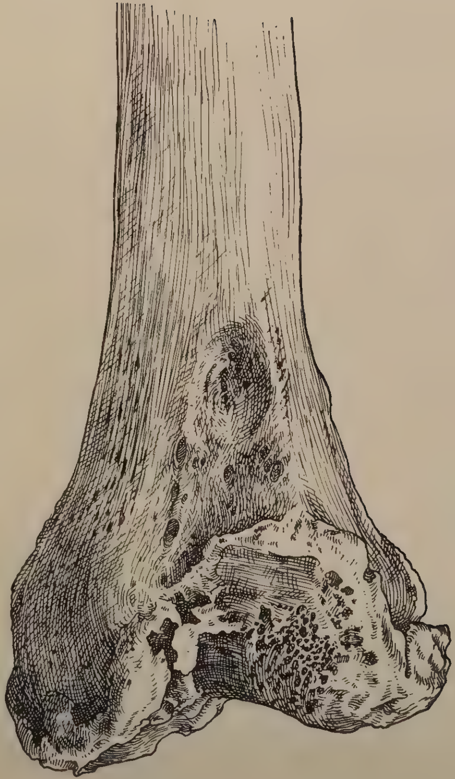

FIG. 5

Drawings of the distal extremities of the femurs shown in Figures 1 and 2 present and also through other soft parts among which a considerable amount of fat frequently must be considered. Hence it seems to me that intermittent, momentary pressure could not have produced these effects, and that they probably are due to pressure resulting from posture. If some of these individuals with arthritis at the knee seek relief by lying in a prone or semi-prone posture, pressures would be exerted upon one or both patellae during rest. It does not follow, to be sure, that supracondylar fossae should hence be present in all persons who habitually occupy such a posture during sleep for a normal cartilage-covered patella manifestly could not produce such localized pressure as a lipped or eroded one. However, since the arthritic lips of the patellae in my possession are very thin and yet not markedly recurved, it is evident that the pressures responsible for this absorption could not have been very large. This also is in harmony with what is known of pressure atrophy. However, it must have been sufficiently large and long continued to interfere with the nutrition of the bone but not severe enough to evoke periosteal reaction for none of these fossae contain any evidence of the deposition of new bone.

THE ANGLE OF GAIT

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This paper presents the findings regarding the angle of gait in 239 males, of which 126 were Stanford University students and 103 boys at the Palo Alto Union High School.

The apparatus used for obtaining the data was a special platform 18 ft. x 4 ft. covered with heavy carbon paper under white paper moved over it by a roller at one end, rotated by a crank. The imprints of each individual were taken by walking over the platform with special shoes equipped with specially placed hobnails in order to get a more perfect imprint on the paper. The platform was long enough to accommodate, on the average, six steps giving three imprints of each foot. The angle of gait was obtained by measuring the angle formed by a median line through the imprints and a line bisecting the platform longitudinally. The averages of these angles on each side were regarded as the angles of gait of the particular individual.

The individuals used were ignorant of the purpose of the records and were told to look straight forward in order to eliminate chance fluctuations as far as possible. Since all were new to the shoes given them the deviations may have been greater than normal although each person was fitted with a pair of gaiters nearest his own size of shoe. Gaiters were used to eliminate unnecessary delay in the taking of records.

The most striking thing observed was the great disparity between the angels of gait on the two sides in the same individual and the inconstancy of the angle on the same side during successive steps. Only six (6) individuals out of 229 had exactly the same angle of gait on both sides, if allowance of one-tenth of a degree is made for errors in measurement. There was only one person in each group that walked wholly without deflection of the feet.

Very few persons toed in on both sides although several toed in on one side and out on the other. Only two out of 103 high school and one out of 126 university students, toed in on both sides, but thirteen high school and nine university students toed in on one side only.

The greatest angle among university students, including graduates,

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UNIVERSITY MEN

FRESHMAN

No.	Average Angle Right	Average Angle Left
6.	12.3	10.5
9.	8.25	5.25
11.	6.5	7.25
12.	4.25	–3.0
16.	8.7	1.0
21.	6.0	9.0
24.	11.1	9.25
25.	5.0	11.0
28.	2.3	3.5
29.	1.25	1.8
30.	5.8	4.16
33.	8.8	4.5
35.	12.8	5.5
37.	8.0	2.75
39.	5.25	3.8
41.	7.1	10.0
42.	14.25	8.5
43.	8.0	2.3
49.	8.5	5.3
53.	9.5	2.6
54.	10.0	7.8
55.	5.0	1.7
56.	14.0	8.5
57.	5.25	0.0
58.	5.0	6.0
59.	1.4	11.6
62.	5.5	2.3
65.	5.25	8.16
66.	8.8	7.6
67.	–3.8	–6.0
69.	2.75	2.25
70.	–5.75	5.16
71.	16.5	14.25
72.	6.0	1.0
74.	8.6	3.25
75.	6.75	3.8
76.	9.25	9.6
77.	8.25	9.16
80.	9.0	4.25
83.	4.0	9.0
86.	7.25	13.8
87.	2.25	5.6
88.	1.5	4.8
89.	8.0	4.16
90.	6.25	8.25
91.	1.5	8.7
92.	9.5	14.8
93.	–0.5	2.25
94.	2.3	–0.5
96.	12.5	15.3
97.	4.16	7.25
98.	5.25	2.0
107.	0.5	2.25
117.	6.5	5.25
124.	9.5	15.5
125.	10.0	11.1
Average	6.46	5.98

SOPHOMORES

No.	Average Angle Right	Average Angle Left
4.	9.8	11.6
7.	0.3	–2.
14.	5.5	3.0
20.	5.6	6.5
23.	4.3	0.66
27.	9.0	2.25
38.	4.5	6.2
47.	8.0	10.16
60.	4.3	9.48
61.	4.3	9 48
63	5.25	2.5
68.	9.0	7.5
84.	15.0	6.0
85.	–1.8	1.0
99.	0.5	4.0
104.	11.6	5.5
111.	0.8	3.8
115.	10.5	5.7
116.	16.8	10.7
120.	4.6	13 1
123.	11.25	13.6
Average	6.62	6.22

JUNIOR

No.	Average Angle Right	Average Angle Left
3.	13.3	13.
19.	13.0	10.0
26.	11.75	6.1
31.	5.0	9.6
100.	6.5	14.5
101.	6.16	3.3
108.	8.5	1.75
110.	6.3	8.2^5
126.	12.25	5.5
Average	9.19	8.00

SENIOR

No.	Average Angle Right	Average Angle Left
17.	2.5	–1.5
34.	16.0	11 0
40.	11.5	11.16
44.	5.5	–2.0
45.	6.5	8.5
50.	5.3	1.5
51.	12.25	8.7
52.	11.00	8.8
78.	8.3	5.0
81.	4.6	4.5
82.	13.5	4.75
102.	5.25	2.3
105.	1.8	4.5
106.	2.0	6.25
119.	1.5	2.6
122.	4.0	7.8
Average	6.96	5.24

GRADUATE

No.	Average Angle Right	Average Angle Left
1.	9.0	4.1
2.	9.8	9.3
5.	3.5	6.6
8.	10.5	14.5
10.	10.8	11.3
13.	2.8	4.25
15.	3.7	3.0
18.	5.25	4.5
22.	13.0	2.6
32.	10.0	5.6
36.	20.3	13.75
46.	10.0	1.75
48.	12.1	9.0
64.	6.16	7.5
73.	13.0	16.5
79.	8.5	11.3
95.	11.16	6.25
103.	3.0	4.0
109.	–3.0	6.5
112.	8.8	2.6
113.	8.0	1.16
114.	17.5	12.6
118.	6.25	12.5
121.	5.0	10.0
Average	8.54	7.54

HIGH SCHOOL MEN

FRESHMAN

	Average Angle	
No.	Right	Left
202.	9.0	5.5
206.	13.5	13.0
207.	3.9	4.0
214.	12.5	7.0
216.	3.5	–2.6
217.	6.2	4.0
218.	13.2	3.5
219.	1.0	4.5
220.	14.6	11.6
225.	7.8	5.7
228.	4.7	–3.0
240.	11 1	10.25
242.	5.0	–3.0
251.	6.0	4.3
255.	–.33	–1.8
283.	6.8	4.7
284.	4.0	3.16
286.	7.6	4.7
292.	3.2	4.0
298.	15.8	13.3
305.	10.1	4.8
308.	15.0	12.0
309.	7.5	1.2
310.	6.0	0.5
314.	0.0	0.0
316.	6.5	3.5
317.	2.0	1.8
319.	12.0	2.8
227.	13.5	8.5
244.	11.3	0.83
245.	10.25	5.0
Average	7.84	4.31

SOPHOMORES

	Average Angle	
No.	Right	Left
127.	12.5	16.0
201.	5.5	3.5
203.	8.7	2.5
209.	17.5	8.0
210.	1.5	5.6
211.	2.5	0.9
212.	1.7	1.0
213.	14.0	14.2
215.	3.0	–2.4
231.	5.2	11.0
232.	10.2	2.2
237.	1.5	9.5
238.	0.75	–0.33
239.	4.25	–0.75
241.	5.25	9.0
246.	–0.5	6.0
247.	11.1	2.5
252.	–2.7	4.3
254.	6.16	6.6
280.	5.25	5.3
290.	2.16	–8.16
291.	3.1	–2.0
302.	6.5	1.6
303.	7.0	8.5
311.	9.5	7.0
313.	2.2	3.0
315.	7.5	1.8
318.	7.8	3.3
320.	18.5	7.5
Average	6.12	3.97

JUNIOR

	Average Angle	
No.	Right	Left
204.	12.0	6.
205.	10.0	10.0
208.	10.5	4.8
222.	11.2	14.0
223.	3.7	5.2
229.	13.	5.5
230.	9.0	4.5
233.	11.1	10.7
235.	11.7	5.0
236.	7.7	4.0
250.	21.0	13.5
275.	6.16	2.6
278.	–1.3	3.5
279.	10.5	13.2
287.	1.83	1.6
288.	11.25	3.8
301.	2.3	3.5
306.	7.6	14.0
307.	4.25	4.16
Average	8.60	6.81

SENIOR

	Average Angle	
No.	Right	Left
128.	8.0	8.4
221.	8.3	12.0
224.	10.2	2.2
226.	–3.2	2.0
234.	4.8	2.7
243.	10.0	12.6
248.	3.75	4.1
249.	4.5	5.1
253.	7.3	8.5
276.	10.16	7.6
277.	7.5	1.8
281.	6.8	6.3
282.	6.1	–.83
285.	7.3	.83
289.	7.3	0.0
293.	11.5	4.8
294.	7.0	9.0
295.	2.5	5.3
296.	9.3	5.8
297.	6.0	6.5
299.	0.0	.3
300.	2.8	–2.5
304.	8.3	0.0
312.	9.0	3.0
Average	6.46	4.39

was 20.3° on the right znd 16.5° on the left. Among high school students these angles were 21.0° on the right and 16.0° on the left. The largest negative angle (toeing in) among university men was 5.8° on the right and 6.0° on the left, making a total range of 26.1° on the right and of 22.5° on the left. Among high school boys the largest

negative angle was 3.2° on the right and 8.2° on the left, making a total range of action of 24.2° on both the right and the left.

TABLE 2

CLASS COMPARISON

Class		Number	Average Angle Right	Average Angle Left	Average of R and L
Palo Alto H. S.		103	7.25°	4.87°	6.06°
Freshmen, University		56	6.46°	5.98°	6.22°
Sophomores,	"	21	6.62°	6.22°	6.42°
Juniors,	"	9	9.19°	8.00°	8.59°
Seniors,	"	16	6.96°	5.24°	6.60°
Graduates,	"	24	7.55°	6.59°	8.04°

Table 2 gives the average angles on the right and left sides. The lowest angles were found in high school boys with an average right and left angle of 6.06°. In passing from freshmen to graduate university students there is a gradual increase in the angle of gait with the exception of the nine juniors who had an average angle of 8.59°. The angle in the latter no doubt is attributable largely if not wholly to the small number of individuals measured and hence may be of no special signifiance.

As shown in table 3 the average angle of gait in university students is greater than that in high school boys.

TABLE 3

	Number	Average Angle Right	Average Angle Left	Average of R. and L.
Palo Alto High School	103	7.25°	4.87°	6.1°
Stanford University	126	7.36°	6.22°	7.2°

In students who came from the athletic field after long football practice, the angle of gait seemed to be larger than in the student not participating in athletics. In other words, the fatigued individual seemed to have a greater angle of gait than the person not fatigued.

Individuals with flat feet as indicated by greater wear on the inner border of the heels, prominent internal malleoli and with altered direction of the upper portion of the back seam of the shoe (downward and inward instead of straight down), seemed to have a greater angle of gait than individuals without these peculiarities.

Table 3 shows that the university man has an angle 1.1° greater than the high school boy, and by observation of aged pedestrians on the street, I got the impression that if data could be collected on such persons they would show a still greater angle. The aged individual probably toes out more because of the greater difficulty in maintaining equilibrium and this may also be the reason why the tired athlete toes out more than he did before he began fatiguing practice. He is unsteadier on his feet.

The consistently larger angle of outward deflection of the right foot may be due to the fact that most persons depend more upon the use of the right leg for the maintenance of bodily equilibrium. However it may also be an expression of better muscular development of the right leg in consequence of greater use for other purposes than the maintenance of equilibrium. It is very interesting, however, that the greater negative angle was found upon the left side in both groups although the difference in the group of university students is so slight that it may be attributed to unavoidable error in making the measurements. This is not true, however, in the group of high school boys in whom a difference of 5% was noticed.

I fully realize that my series of measurements is regrettably small and that the results obtained must be regarded as purely tentative. Nevertheless I feel justified in reporting them and am grateful to Dr. Meyer for suggesting the topic and method and for his guidance of this investigation.

THE PROSPHENION

JOHN CAMERON
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The prosphenion is defined by Duckworth[1] as "the uppermost limit of the spheno-ethmoidal junction" in the mesial sagittal plane of the skull. Its significance may be gauged from the fact that it is utilized in the measurement of the important spheno-maxillary angle, which was devised by Huxley.[2] He employed this angle to great purpose in his classical researches on the cranio-facial axis, and it is regarded today as possessing a certain degree of significance as an index of prognathism. It is likewise the most important cranial "point" in the measurement of two other angles—the spheno-ethmoidal and the foramino-basal, both of which are regarded as of significance in craniometry. It is therefore clear that no dubiety ought to exist regarding the exact location of the prosphenion. Unfortunately grave dubiety does exist, and this state of affairs is aggravated by the fact that very few textbooks on craniometry refer to its existence, far less to its importance.

The attention of the writer was directed first of all to this difficulty during an examination of two New Hebridean crania.[3] These had belonged to individuals at or beyond middle life, and it proved a matter of grave difficulty to my colleagues and myself to be able to define with any degree of certainty the site of the prosphenion. Therefore it appeared to us that the line of the spheno-ethmoidal junction must become obliterated during adolescence. The writer tested this point in a mesial sagittal section of the cranium of an Eskimo, known definitely to have been under thirty years of age. Even in this case I was totally unable to locate the prosphenion. An examination of mesial sagittal sections of adult Anglo-Saxon skulls yielded in practically every instance the same degree of dubiety. It was therefore evident that the position of the prosphenion could only be located with tolerable certainty in young growing crania, and it was perfectly obvious that these could not be utilized for comparative craniometry.

If the spheno-ethmoidal junction be examined in disarticulated cranial bones, it will be noted that the sphenoidal portion is usually in the form of a jagged point which may assume all sorts of fantastic shapes, and

[1] Morphology and Anthropology, Cambridge University Press; p.247
[2] *J. Anat.*(quoted by Duckworth)
[3] *Trans. N. S. Instit. Sci. xiv. Part 4.*

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therefore presents nothing definite or convincing. Moreover the notch in the posterior edge of the ethmoid into which this fits displays corresponding degrees of variation. If there existed, for example, a groove or a ridge to mark the junction, matters would be different, but in the absence of these the prosphenion becomes self condemned as wholly unreliable. It may be added that it is unfortunately not the only craniometric point that presents grave objections.

Destructive criticism is all very well, but it is essential that something constructive be offered that will bear the closest analysis and scrutiny. If the basis cranii be examined in the vicinity of the spheno-ethmoidal junction for any possible substitutes to replace the prosphenion it will be found that two points are perhaps worthy of consideration. In the case of the ethmoid there is the crista galli which is at once condemned as being very variable both in size and form in different individuals. In the case of the sphenoid, however, I would suggest two points. For instance, the anterior edge of the groove for the optic commissure is often very sharply defined, and in such cases presents a readily located craniometric point in mesial sagittal sections of the cranial base. In other instances it may be only very faintly marked, but my experience is that it can usually be detected in such sections. The term "commissural point" is suggested by the writer as a possible appellation for this. Just behind this again one meets with the anterior edge of the pituitary fossa. (It may be noted here that Welcher selected this point for his cranial angle.) Unfortunately it likewise displays great variations in its sharpness of definition, when examined in sagittal sections, but on the whole it permits of being located with a fair degree of precision, and might accordingly be termed the "pituitary point." It may be added that the commissural point is only a few millimetres behind the prosphenion, and it proved interesting to compare the effect its utilisation had on the dimensions of the spheno-maxillary angle. This was tested out in a series of crania—anglo-saxon, melanesian and eskimo, and the difference in size only amounted to from one to five degrees—sometimes more and sometimes less. It would not be feasible or advantageous to proceed further back behind the pituitary point in our search for other possible points to replace the prosphenion, as the values of the spheno-maxillary, spheno-ethmoidal and foramino-basal angles would be seriously impaired thereby. The most serious indictment against the prosphenion is its relation to the point at which the cranio-facial axis becomes flexed upon itself. This however introduces considerations of so vast a character, that they are to form the subject of a separate communication.

NOTES

NEW PERIODICAL DEVOTED TO PHYSICAL ANTHROPOLOGY. The Anthropological Institute of the Czech University of Prague has commenced to publish a new Journal under the title of "*Anthropologie*" to be devoted exclusively to Physical Anthropology. The publication will have the same broad basis as, and will in other points resemble, the AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY. It is edited by Professor J. Matiegka with a number of Associate Editors in the different Slavic countries. The Journal is to pay special attention to anthropological work among the Slavs, helping to make it known to the rest of the world. The first number issued in March, 1923, printed on good paper, brings the following communications: The aims and needs of anthropology with special regard to Czechoslovakia, by Aleš Hrdlička; Anthropological study of musculature, by Dr. E. Loth; Peculiarities of the venus sulci of the diluvial crania of Předmost, by J. Matiegka; Bathrocephaly, by J. Hochsinger; Changes in the population of Bohemia and Moravia during the great war, by F. J. Netušil; Contribution to the demography of the Huculi (Carpathians) by V. Suk; The somatological age, by J. Matiegka. In addition to this there are numerous reviews of literature and anthropological notes. A valuable feature of the Journal is that all the original communications are accompanied by a good abstract in French or English. Three additional numbers, equally as creditable, have been received since.

Considering the usual difficulties with the otherwise rich Slav literature in anthropology, this is a most welcome publication and one which will be quite indispensable to English workers in physical anthropology. The subscription price is 80 CS crowns ($2.50) less than half that for which a similar journal could be furnished in this country. Address: "Anthropologie," Anthropological Institute, Prague II, 2027 Karlov 3, Czechoslovakia.

NEW JOURNAL. Under the title of "*Anthropologia Hungarica*," a new anthropological Journal has been established under the auspices of the Ethnographic Society of Hungary in Budapest. It is to be devoted to physical anthropology and the first three numbers contain ten communications on various subjects in this line.

The journal is edited by Dr. Louis Bartucz, VIII ker., József-utca 5, I., 11 Budapest, Hungary. The subscription price is 10 Swiss francs a year.

JOURNAL DE LA SOCIETE DES AMERICANISTES DE PARIS. It is a pleasure to call attention to the real and steadily increasing value of this Journal to American anthropology of all branches. Vol. XIV, 1922, brings in its 324 pages a series of original articles of importance, among which may in this place be mentioned those of Henry Vignaud on the

Peopling of America and of R. Le Conte on *German Colonization in America*, and of Baron Marc de Villiers on *Documents relating to the Indians of Louisiana.* In addition there are very good obituaries, numerous reviews, and thanks to Dr. Rivet a copious bibliography of publications relating to American anthropology. Vol. XV, 1923, comprising 448 pp., is even richer than the preceding. It gives besides original articles and bibliography, very rich and useful notes on anthropological research in all parts of the two Americas. The Journal deserves not merely all possible credit but also the fullest support of every Americanist. (Address 61 Rue de Buffon, Paris; 30 francs, i. e., $2.00).

ANTHROPOLOGY IN SPAIN. During his recent visit to Spain, the writer was pleasantly surprised to find not merely a growing interest in Anthropology but also excellent somatological and archaeological collections which are not as well known as they deserve to be. The principal collections are found in the *Museo Nacional de Ciencias Naturales*, and in the separate *Museo de Antropologia* directed by Professor Manuel Antón y Fernández, both in Madrid. The collections overlap; nevertheless those of the Museo Nacional comprise essentially prehistory, those of the Museo de Antropología essentially physical anthropology, including a large and valuable series of crania. Perhaps some day it will be possible to join these two into one great collection, which would greatly strengthen the status of anthropology in the whole country. The progress in anthropological research has led, in May of 1921, to the organization of the "Sociedad Español de Antropología, Etnografia y Prehistoria," and towards the end of the year the establishment of the "Actas y Memorias" of the Society. The first number of these, published in 1922, brings besides the bylaws, membership, records of meetings and reviews, articles by Ignacio Bauer, on "El Rif y la hábila de Beniurriaguel," pp. 3–13; Manuel Hilario Ayuso, on "Un nuevo antropómetro," 15–22; Juan Cabré Aguiló, on "Una necrópoli de la primera edad de los metales, en Monachil, Granada, 23–36; C. de Mergelina, La necrópoli tartesia de Antequera, 37–90; and Louis de Hoyos Sainz, on "Cuestionario y Bases para el Estudio de los Trajes Regionales, 91–96. The address of the Society and the periodical, to both of which we wish continued success, is Museo Nacional de Antropología, Paseo de Atocha, 13, Madrid.

TRABALHOS DA SOCIEDADE PORTUGUESA DE ANTROPOLOGIA E ETNOLOGIA. The fourth number of Vol. I, 1922 of this periodical, brings the following interesting communications: Alfredo Athayde—Sobre algumas correlaçoes faciais, pp. 197–215; J. Bethencourt Ferreira, Amélia Bacelar & F. F. Viegas da Costa—Sobre o indice condiliano, como determinante sexual do crânio, pp. 217–227; J. A. Pires de Lima—Um caso de braquidactilia hereditária, pp. 229–238; Hernani B. Monteiro—Multilações dentárias da região do Humbe, pp. 239–265; Fabio Frassetto—Inspecção internacional da infância e a classificação morfológica das crianças, pp. 267–277; A. A. Mendes Corrêa—Prof. V. Giuffrida-Ruggeri, pp. 279–285.

New Anatomical Journal. Under the title of "Folia Anatomica Japonica" the Japanese have begun (March, 1922) to publish a new journal of anatomy. The articles are printed in German or English. The journal is edited by K. Okajima, assisted by a large number of associates. The first number, which makes a good appearance, brings two papers of interest to anthropology, namely, K. Okamoto—*On the gastric triangle of the Japanese;* and G. Takata—*On the value of bones as diagnostic material of fetal age.* (Address: Yotsuya, Tokyo. Price $8.00 per volume).

New Journal. Under the name of "Inca" Dr. J. C. Tello has in 1923 commenced the publication of a "quarterly review of anthropological studies," at Lima, Peru. The Journal is "the organ of the Archeological Museum of the University of San Marcos," Lima, and is to serve anthropology in all its branches. Thus far three numbers have appeared, with very creditable contents. The Journal is of good appearance, and means a substantial advance in the anthropology of Peru.

New Periodical. The healthy growth of interest in Anthropology of all branches on the American continent is shown by the recent appearance of still another anthropological serial This is the "Publicaciones del Museo de Etnología y Antropología de Chile," published at Santiago de Chile, under the auspices and direction of the Museum. This Journal will also bring the results of research in all branches of Anthropology. So far seven numbers have been received dating from 1917–1922.

New Anthropological Journal in Europe. Under the title of "Anthropologischer Anzeiger" Professor Rudolf Martin, in cooperation with a number of his colleagues has commenced (1924) to publish a "review of literature in physical anthropology." The serial will also bring, however, original communications. Inquiries are to be addressed to Professor Rudolf Martin, Direktor des Anthropologisches Institut, Neuhauserstrasse 51–3, München, (Bayern) Germany.

Die Eiszeit. The importance of the many unsolved questions concerning the Ice Age and the relation of same with Early Man, has led Professor Josef Bayer, the present Director of the Museum of Natural History in Vienna to establish a periodical devoted exclusively to this subject. The first "Heft" has just appeared. The periodical, it is self evident, will deal not only with the anthropology but with the geology and paleontology of the Ice Age.

Russkij Antropologicheskij Jurnal. The first and second instalments of Vol. XIII of this valuable Journal have just been received after prolonged difficulties with publication. The number is devoted exclusively to physical anthropology, bringing communications on the subject of the skull of the Pithecanthropus; on the relation of the height of the head and the length of the body in children; on Nanism and endocrine glands; on the skin and on the soft parts of the face in the Kirghiz;

on the acclimatisation of human races; on the anthropological characteristics of the tuberculous; and on typical constitutions in man. In addition to which there is an obituary of Professor Anuchin, numerous reviews, news and bibliography.

THE SECOND PAN-AMERICAN SCIENTIFIC CONGRESS will meet in Lima, Peru, November 16, 1924. Section I of the Congress is devoted to Anthropology, History and related sciences. Those who may wish to attend should communicate with Sr. José J. Bravo, the Secretary General, Apartado 889, Lima, Peru

The two sessions of the XXI International Congress of Americanists, to be held respectively at La Hague (Aug. 12–16) and at Gothenburg (Aug. 20–25), promise to be of more than the usual importance. A good American representation is assured.

THE ROYAL ANTHROPOLOGICAL INSTITUTE has founded a Rivers memorial in memory of Dr. W. H. R. Rivers, who was president of the institute at the time of his death The medal will be awarded for special meritorious anthropological work in the field. All British subjects and anthropologists of other nations who are fellows of the institute will be eligible.

CALIFORNIA BUREAU OF JUVENILE RESEARCH. The California Bureau of Juvenile Research is a department of Whittier State School, of which Mr. Fred C. Nelles is superintendent. Recent legislation extends the functions of the Bureau to other institutions, and permits affiliations with universities and other organizations. The functions of the Bureau are wide, but its essential purpose is "to carry on research into the causes and consequences of juvenile delinquency, mental deficiency, and related problems." To do this, authorization is given for the carrying on of any type of investigation that may be advantageous. *Eugenical News*, April, 1922, 53.

A local branch of the *Royal Anthropological Institute* has been established for Edinburgh and the Lothians.

NATIONAL OFFICE OF EUGENICS IN BELGIUM. On October 10, 1922, there was inaugurated at Brussels a Belgian National Office of Eugenics. Its headquarters are at the Solway Institute, the Director is Dr. A. Govaerts, assisted by W. Schraenen, Anthropologist. At the meeting of the International Eugenic Commission in Antwerp, the mayor of the city announced that an appropriation had been made for a branch office of the National Office of Eugenics, to be located at Antwerp.

THE SWEDISH STATE INSTITUTE OF RACE BIOLOGY was established in 1921 in Sweden under the auspices (though not the full financial support) of the Government, and Professor H. Lundborg has been named its Director (see Lundborg (H.), *Acta Med. Scand.*, 1922, LVI, 371–392). The Institute is to be devoted to research in heredity and genetics, anthropology, genealogy, demography and racial pathology, and is to have a Museum of Heredity. "The scientists connected with the Institute, the race-biologists proper, all of them need a solid education in anthropology." The Institute has its own council, appointed by the King and standing directly under the Government. At present it is located at Upsala and the director is nominally on the University staff; but the Institute is a governmental rather than University department or agency.

The Bureau for the Study of Defective Children in Prague, Czechoslovakia, has been joined to the *Anthropological Institute* of the Charles University in that city.

THE INSTITUTE OF ANTHROPOLOGICAL SCIENCES of Warsaw (Director, K. Stolywho) reports[1] for the years 1921–'3 the following main activities: (1) There has been realized the fusion with the Institute of the Bureau of Military Anthropology and under the joint auspices of the two 41,183 soldiers were examined; the results are being analyzed and prepared for publication. (2) The Institute has received the important prehistoric collections of Erasm Majewski comprising more than 30,000 catalogued specimens. (3) Scientific work and publication is being carried on effectively notwithstanding the serious difficulties under which the country still labors. Progress has been made in the study of the anthropological composition of the Polish people, and field research on ancient man in the Polish territories.

Anthropological research has been added to the work at the *Medico-Pedagogical Institute for the Study of Children*, Petrograd, Russia.

JINDRICH MATIEGKA. A special number of the *Národopisny Vestnik Ceskoslovansky* (*CS Ethnographic Bull.*, 1922, XV, No. 2) is dedicated on the occasion of his 60th birthday to Professor Matiegka, the leading anthropologist of his country. It contains the following articles: V. *Suk-Jindrich Matiegka*, his work and bibliography; *Prehistory and Ethnography*, by A. Stocky; *Early History of Carpathian Russia*, by L. Niederle; *Anthropology of the Subcarpathian Slavs*, by V. Suk; *Anthropology, Constitution and Psychiatry*, by K. Herfort; *Pedology and Ethnography*, by J. Dolensky; *The Modern Tasks of Physical and Psychical Research on Children*, by C. Stejskal; *The Influence of the War on the Bodily Development of Prague Boys*, by L. Lukášova; and *Religious Symbolism of the Older Stone Age in Bohemia*, by J. Schránil.

ANTHROPOLOGICAL TEACHING IN ENGLAND AND SCOTLAND. According to the first report of the *Committee on Progress of Anthropological Teaching* in these countries, Instruction in Physical Anthropology is given in the following institutions:

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[1] In a special communication to the JOURNAL.

ENGLAND

Bristol.—Professor E. Fawcett gives instruction in Physical Anthropology at the University, which is included for the curriculum for the degree of B.Sc. in Human Morphology.

Cambridge.—The University has important collections in Physical Anthropology Dr. W. H. L. Duckworth gives instruction in the subject.

Liverpool.—Instruction in Physical Anthropology at the University is given by Dr. W. H. Broad.

London.—The Royal College of Surgeons has very important collections in P. A. There is accommodation for research students, but no formal instruction is given.

At the University College instruction in P. A. is given by Professors G. Elliot Smith and Dr. Karl Pearson.

Kings College has anthropological collections, with laboratory accommodations for research students; instruction in P. A. is given by Professor E. Barclay-Smith and Mr. R. J. Gladstone.

The Francis Galton Laboratory for National Eugenics has large collections in P. A., and a laboratory accommodation for 12–18 students. There is a studentship for anthropometry and arcniometry. The laboratory is one of the most complete of its kind. Instruction is given, but no regular courses.

The Natural History Department of the British Museum, in South Kensington, has valuable anthropological collections, including the Piltdown remains and the Rhodesian skull, and facilities are given to well qualified students for studies.

The London School of Economics and Political Science has some collections, and instruction in P. A. and related fields is given by Professor C. G. Seligman.

Academic Status of Anthropology in London: In the University of London, Anthropology may be offered in Honors and Pass Examinations for the degrees of B.A. and B.Sc., and as an optional subject in the B.A. Honors course in Geography; it is recognized as a subject for the degrees of M.A., M.Sc., D.Litt., and Ph.D., for the diploma of Psychology and for the College Certificate in Egyptology. An attempt is now being made by the constituent colleges to make full provision for teaching and research in all departments of Anthropology. The Royal Anthropological Institute, on the invitation of the British Association and other bodies interested in anthropological studies, has established a joint committee, on which such bodies are entitled to be represented, with the object of ensuring to students from the Dominions and foreign countries all needful facilities for their researches, and information as to material available in public archives and in private collections.

Nottingham.—The University College has a working collection of human osteology; Dr. H. H. Swinerton and Miss H. J. Hutchinson give instruction in Physical Anthropology.

Oxford.—The University has important collections in Physical Anthropology, with accommodations for research students. Regular courses in P. A. are given by Professor Arthur Thomson, and by Dr. L. H. Dudley Buxton. A diploma in Anthropology is awarded on courses of study of at least one year, and this diploma is reckoned equivalent to two of the three subjects required for the ordinary degree. Separate Certificates are awarded for proficiency in Physical and in Cultural Anthropology, each equivalent to one such subject for the degree of B.A. Anthropological research is admissable for the degrees of B.Litt., B.Sc., and Ph.D. Special provisions are made for officers of public services who have been sent by the Colonial Office for short courses of anthropological study, and for candidates and probationers of the Indian Civil Service.

Sheffield.—The University has a small collection of crania and skeletons, and Dr. C. J. Patton, Professor of Anatomy, gives instruction in Physical Anthropology as required.

Wales.—In the University of Wales, Anthropology is an important part of the Honors course in Geography for the degree of B.A., and is a recognized subject of research for the post-graduate diploma in Geography and for the degrees of M.A. and M.Sc.

At the University College of Aberystwyth instruction in Physical Anthropology is given by Professor H. J. Fleure.

At the University College at Cardiff, the Professor of Anatomy and Anthropology, Dr. D. Hepburn, gives instructions in Physical Anthropology, which is a compulsory subject for students of Medicine.

SCOTLAND

Aberdeen.—The University of Aberdeen has Museums of Anatomy and Anthropology, and an Anthropometric Laboratory. The Professor of Anatomy, Dr. R. W. Reid, gives instruction in Physical Anthropology, which is a subject qualifying for the degree of B.Sc. A students Anatomical and Anthropological Society meets regularly for lectures on these subjects by experts, and discussions.

St. Andrews.—The University of St. Andrews has a fairly representative collection in Physical Anthropology. There is laboratory accommodation for research students in this branch, which is included in the Department of Anatomy. The Professor of Anatomy, Dr. D. Waterston, gives instruction in Physical Anthropology, which may be taken as a part of the course for the degree of M.A. and B.Sc.

Edinburgh.—The University of Edinburgh has a large and valuable collection of crania and other parts of the skeleton, including 298 skulls of the Australians. The Professor of Anatomy, Dr. A. Robinson, gives instruction in Physical Anthropology, which is a subject qualifying for the degree of B.Sc. In addition the Munro Lecturer gives each year ten lectures on Anthropology or Prehistoric Archaeology.

Glasgow.—The University has a fiar collection in Physical Anthropology; and instruction in that subject is given by the Professor of Anatomy, Dr. T. H. Bryce.

At a session of the DIVISION OF ANTHROPOLOGY AND PSYCHOLOGY OF THE NATIONAL RESEARCH COUNCIL held on April 27, 1924, a committee was appointed with Professor Ernest A. Hooton of Harvard University as Chairman for the purpose of raising a sufficient endowment fund to enable the AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY to meet its present yearly deficits and to enable it to enlarge the size of the quarterly numbers from 112 to 124 or more pages. Contributions to the fund, which is to be deposited at the Smithsonian Institution, should be sent to Professor Hooton.

Dr. Charles Haskell Danforth, well known for his researches in anthropology, has been appointed associate professor of anatomy in the Medical School of Stanford University.

Dr. M. Inouye has been appointed Director of the Anatomical Laboratory of the Tokio Imperial University. The laboratory has important anthropological collections.

Dr. George Grant McCurdy, Curator of Anthropology in Yale University, has been appointed Research Associate in Prehistoric Archeology at the University, with professorial rank

†Professor Felix Von Luschan died in Berlin, February 7, 1924, in his 70th year.

†Dr. Edward Anthony Spitzka, known for his valuable anthropological and anatomical contributions to the study of the brain, died September 4, 1922. He was but 46 years old.

†Professor Dmitrij N. Anuchin died on June 4, 1923, in the 75th year of his age and in the 43rd year of his connection as Anthropologist with the Moscow University.

†G. Stanley Hall,president emeritus of Clark University,distinguished for his contributions to psychology, died on April 24, aged seventy-eight years. Professor Hall was one of the Associate Editors of the AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY from its commencement until 1923.

American Journal of Physical Anthropology

Volume VII JULY–SEPTEMBER, 1924 Number 3

THE THEORETICAL DISTRIBUTION OF HEREDITARY TRAITS IN MAN

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It is not universally admitted that the Mendelian mode of heredity is the only one that is operative in human genetics. But when the term "Mendelism" is made to include "Neo-Mendelism" and those extensions and refinements of the original concept which have led to the modern theory of the gene, it may confidently be asserted that the hypothesis is the most satisfactory one that has yet been proposed. But while the general features of the theory are well understood, there are a few implications and some related practical considerations that deserve at least occasional emphasis in anthropological literature. One of these relates to the expected distribution of recessive traits, in human populations.

According to the theory, individual characteristics are due to the interaction of a large number of germinal factors whose resultant effect is more or less modified by conditional factors, which may be understood to include all environmental influences. The germinal factors, or genes, are conceived to be discrete morphological entities, and are the real hereditary units. It is generally assumed that a given germ cell has no strictly duplicate genes, each gene being in some degree different from all others in the same sex cell.[1] At fertilization the union of two sex cells brings homologous genes together in pairs so that in the resulting cell every gene, unless it happens to be located in the odd sex chromosome of the male, is duplicated, the members of each pair being morphologically essentially equivalent and representing the respective

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[1] The polyploid condition sometimes encountered in plants is as yet unknown in the mammals.

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contributions of the two parents. In cell division the genes divide into quantitatively and qualitatively equal daughter genes which are passed on from generation to generation, unchanged except for the rare occurrence of mutations. It is assumed that in a given individual each germ cell (before reduction) and each somatic cell contains the same complement of genes as every other cell in the same subject.

As a result of mutation some homologous pairs may be made up of genes which are not strictly identical and are consequently known as allelomorphic. If the two genes of a pair are alike the individual in which they occur is homozygous for that pair. If they are different he is heterozygous. When heterozygosis occurs, one gene of a pair may produce its full effect (i. e., act as a dominant) while the allelomorphic gene is seemingly wholly suppressed (recessive), or both genes may show evidence of their presence through some form of blending inheritance. But heterozygosis is not known to have any effect on either the dominant or the recessive gene, so that a trait may reappear in its original form after having been suppressed for any number of generations. This presumed permanence and relative immutability of the gene is the most important aspect of the theory since it implies that the germinal constitution of a population remains constant except as genes of one type tend to eliminate themselves through endowing their possessors with traits which are biologically less favorable than those produced by allelomorphic genes. Stated in other words, in the absence of differential net fecundity the character of the germplasm of a population as a whole should remain constant irrespective of how heterozygous the population may be and irrespective of what particular matings occur. A rough analogy is afforded by chemical substances of known amounts in which the number of atoms of each kind remains constant however the substances may be combined and recombined.

Thus, if in the germplasm of a given population the genes for two allelomorphic traits, such as brown and blue eye color,[2] were to occur in the relative frequency of, say, 4 to 6, and marriages were always between individuals with the same color of eyes, there would be approximately four brown eyed individuals to every six with blue eyes, unless one group had a greater net fecundity than the other. It is an important corrolary of the theory that any other system of mating would not change the ratio of the two types of genes[3] although, since one trait is dominant, it might result in a modification of the relative number of brown eyed and blue eyed persons. This means that mate selection cannot of itself alter the fundamental constitution of a population, whatever ephemeral difference it may make in the apparent distribution of traits. It is not till the factor of differential reproduction is introduced that the germplasm of a population may be really changed.

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[2] This illustration is chosen simply as a paradigm. The precise frequency of blue eyes, the possibility of more than one form of blue-eyedness, especially in mixed mongoloid and white strains (Cf. O. Winge, Compt. Rend. Lab. Carlsberg 14, 1921), and the effect of epistatic factors in relation to the darker shades of eye color, are matters not closely related to the purpose of this paper, which is simply to call attention to a few aspects of the Mendelian theory as related to whole populations in contrast to individual families.

When matings are wholly without reference to the members of a pair of allelomorphic traits the distribution of genes in a population should be according to the laws of chance distribution of two kinds of objects taken two at a time, i. e., the three possible combinations should be proportional to the three terms of the expansion of $(a + b)^2$ where a represents the frequency of one gene and b that of its allelomorph. With a relative incidence of 4 to 6 (which is apparently the ratio of the genes for brown and blue eyes in some parts of this country) the three classes, (i) homozygous for the first gene, (ii) heterozygous, (iii) homozygous for the second gene, should be proportional to the terms in the algebraic expansion of $(4 + 6)^2$, or 16: 48: 36. In the case of eye color, where brown is dominant, the heterozygous individuals would also be dark eyed giving a total of $16 + 48$, or 64, brown to 36 blue eyed subjects.

Conversely, it follows that if in a population of N individuals there are n that show a simple recessive trait the ratio of dominant to recessive genes is $(\sqrt{N} - \sqrt{n}) : \sqrt{n}$. When n is stated in per cent the ratio is $(10 - \sqrt{n}) : \sqrt{n}$. So when a reasonably stable population is found to include blue eyed subjects to the extent of 36 per cent it may be inferred that in that population the relative number of genes for brown and for blue eyes is in the ratio of $(10 - \sqrt{36}) : \sqrt{36}$ or 4: 6, and with this information it becomes possible to reconstruct the probable constitution of the whole group as indicated above. Then, still assuming that there is no selective marriage rate, the theoretical frequency of different types of marriage and the expected distribution of dark and light eyed children can be computed as indicated in the accompanying tabulation, where *B* stands for the dominant gene and *b* stands for the recessive. It is apparent that in random mating the distribution of traits is the same in the filial as in the parental generation and that the relative number of genes remains constant ([2 x 1600] + 4800:: 4800 + [2 x 3600] :: 4:6) so long as the average rate of reproduction is the same for all groups.

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[3] The writer has discussed this point more fully in a paper on "The Frequency of Mutation and the Incidence of Hereditary Traits in Man" (*Eugenics, Genetics, & The Family*, 1923, I, 120.). A discussion of the mathematical aspects of the question and a review of the literature may be found in a series of four articles by Sewall Wright appearing in *Genetics*, 1921, VI, under the general title "Systems in Mating", and in a paper on "Some numerical proportions in panmictic populations," by L. Baas Becking in *Recueil trav. bot. neerl.*, 1918, XV, 337-365.

From such a tabulation a variety of expected relations may be worked out and used to test observational data. Thus it may be deduced from the last column of the table that under the conditions stated the greatest absolute number of blue eyed children should come from the class of families in which one parent is blue eyed, the other brown, and that a considerable number should come from families in which both parents have brown eyes. It appears from the preceding column that 7.68 per cent of all individuals are heterozygous subjects whose parents, brothers and sisters are dark eyed. When two such individuals marry they will produce on the average one blue eyed child in four. Consequently with small families there should be an occasional blue eyed child whose brothers and sisters, parents, uncles, aunts, and grandparents are all dark eyed. With the recessive trait showing an incidence of 36 per cent such cases should be rare (about 7 per cent of all blue eyed persons if the average number of children to the family is three), but when recessive genes are relatively less numerous this group is greatly increased and the condition may consequently come to be thought of as one which frequently is not hereditary at all. This phase of the matter is of considerable importance in connection with the distribution of some diseases. To cite only one illustration, it is stated in medical texts that diabetes mellitus occurs in about .2 to .3 per cent of individuals and that heredity is indicated in from 20 to 30 per cent of diabetic cases. In view of this incidence of the disease and the limited extent to which family histories

TABLE 1.—THEORETICAL DISTRIBUTION OF BROWN AND BLUE EYE COLORS WHEN THE RELATIVE FREQUENCY OF THE TWO GENES *B* AND *b* IS AS 4 TO 6.

Germinal constitution of the parents		Frequency of Mating		Distribution of traits among the offspring		
				BB, homozy brown	*Bb*, heterozy brown	*bb*, blue
BB	*BB*	16x16	256	256	....	....
BB	*Bb*	16x48x2	1536	768	768	....
BB	*bb*	16x36x2	1152	...	1152	....
Bb	*Bb*	48x48	2304	576	1152	576
Bb	*bb*	48x36x2	3456	...	1728	1728
bb	*bb*	36x36	1296	...	....	1296
Total			10,000	1,600	4,800	3,600

are usually followed up clinically, this is about what would be expected if all cases of diabetes were in fact hereditary;[4] assuming, of course, a population in which marriage selection is not greatly restricted by artificial barriers.

With sex-linked traits the determining gene is located in the X chromosome and consequently, while the distribution among females is the same as if the gene were in any other chromosome, in the male sex there can be no heterozygous class and the relative frequencies of two allelomorphic traits are the same as the frequencies of their respective traits. These frequencies having been determined directly from the male part of the population, their expected frequency among females may readily be computed.[5] It turns out that if among males the frequency of a trait is $\frac{a}{b}$ the frequency among females will be $(\frac{a}{b})^2$ if the trait is recessive and $\left(\frac{a}{b}\right)^2 + \frac{2\,a\,(b\text{-}a)}{b^2}$ if it is dominant.

In dealing with all problems of this sort the number of children to the family is a matter of considerable importance in computing the expectation,[6] for it is evident that when it is a question of the appearance of a recessive trait in only one of the children from a pair of heterozygous parents, the phenomenon should be expected much more frequently when the average number in the family is small than when it is large. If the number of children to a family were four, it would be expected that of all families with heterozygous parents 42 per cent would have only one child each showing the recessive trait, but if the average number of children were ten the percentage of such families would fall to about 20. This is a point that has to be borne in mind when conclusions are drawn from the distribution of traits among the children of a selected group of families. It should be noted in passing that since, mathematically, there is a definite expectation for each size of family, computations based on averages are not strictly accurate, although they are generally sufficiently so for practical purposes.

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[4] If all cases of diabetes were due to the action of a recessive gene and if the incidence of the disease corresponded to .25 per cent of the population, then, according to Mendelian expectations, approximately 72 per cent of cases (varying somewhat with the average number of children to the family) should show a negative family history to the extent that these patients would have non-diabetic brothers and sisters, parents, uncles, aunts, and grandparents.

[5] Aspects of this matter are discussed by the writer in the *American Naturalist*, Vol. 58, pp. 00.

[6] Cf. W. Weinberg: Weitere Beiträge zur Theorie der Vererbung. Arch. f. Rassen- u. Gesellschaftsbiol., Vol. 9, pp. 165-174; 1912.

While most often Mendelian analysis proceeds from parent to offspring, the frequently greater availability of children may sometimes make it desirable to reverse the procedure. When this is done it is again necessary to take account of the error that tends to be introduced by the prevailingly small size of families. While this phase of the subject has been commented upon by Boas[7] and others a brief generalized statement of the expectations under these conditions may not be out of place in this connection. The situation is as follows:

In a population where two allelomorphic traits B and b occur there will be a certain number of marriages (which may be represented by m) between individuals both of whom are heterozygous. With all such marriages the chances are three to one, or $\frac{3}{4}$, that the first child will show the dominant trait, B. The probability that the second child will also show the dominant trait is likewise $\frac{3}{4}$. The consequent probability that two successive children will both show this trait is $\frac{3}{4} \times \frac{3}{4}$ or $(\frac{3}{4})^2$, and that n successive children will show the trait is $(\frac{3}{4})^n$. Consequently in a group of matings between pairs of heterozygous parents each with n children the relative number which will produce only children showing trait B is $(\frac{3}{4})^n$ as compared to $1 - (\frac{3}{4})^n$ which represents the couples which will produce at least some children showing trait b. According to Mendelian expectation, however, the total number of b-children from these matings is $\frac{mn.}{4}$. But all of these are produced by $m\ [1 - (\frac{3}{4})^n]$ pairs of parents with an average of n children to the family. From this it follows that in families where b-children occur at all, their frequency is indicated by $\frac{mn}{4}$ divided by $mn\ [1 - (\frac{3}{4})^n]$, or $\frac{1}{4\ [1 - (\frac{3}{4})^n]}$. In other words the familiar fraction $\frac{1}{4}$ representing the number of recessives that segregate out when two heterozygous individuals are mated must be multiplied by the correction factor $\frac{1}{1 - (\frac{3}{4})^n}$ to give the real expectation when the only families considered are those which produce at least one child with the recessive trait, and that, often times, is the only available criterion of heterozygosis on the part of the parents. Under similar condition the correction factor, when the expectation is $\frac{3}{4}$, is $\frac{1}{1 - (\frac{1}{4})^n}$

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[7] Boas, Helene M.: Inheritance of Eye-Color in Man; Amer. Jour. Phys. Anthrop., Vol. 2, pp. 15-20, 1919.

and when the expectation is ½, $\frac{1}{1 - (\frac{1}{2})^n}$. The true expectations may be anywhere between 1 and ¼, ½, or ¾, depending on the value of n. When n represents an average number, as would usually be the case, these correction factors are only approximately accurate.

The foregoing discussion is applicable to traits whose presence or absence is determined by a single pair of allelomorphic genes. When a trait of this sort is dominant its distribution presents few difficulties,[8] but when it is recessive the points that have been indicated must be taken into account in studying the distribution in whole populations as contrasted with individual families. When the trait is due to the concomitant action of two or more genes (or, stated more accurately, when the population is to some extent heterozygous for two or more of the many genes upon which a manifestation depends), calculation of expectations becomes considerably more difficult. In controlled animal or plant breeding, analyses of situations of this sort are relatively simple, but in human populations they are especially baffling owing to the difficulty of determining the number of factors involved and the relative frequency of each.[9] When the frequencies are known or can be estimated it is convenient to designate allelomorphic genes by successive letters. When there are two allelomorphic pairs involved the genes may be indicated as a and b, c and d. By also assigning to these symbols values corresponding to the frequencies of the respective genes computations may be greatly simplified. The theoretical distribution of combinations under these circumstances is proportional to the terms of the expansion of $(a + b)^2 (c + d)^2$. The nine terms in this series may conveniently be arranged in the following tabular form:

$$\begin{array}{ccc} a^2 c^2 & 2\,a\,b\,c^2 & b^2 c^2 \\ 2\,a^2 c\,d & 4\,a\,b\,c\,d & 2\,b^2 c\,d \\ a^2 d^2 & 2\,a\,b\,d^2 & b^2 d^2 \end{array}$$

In this arrangement, the first and second powers represent, respectively, hetero- and homozygosis, and the product of the values represented by the symbols and the coefficient indicates the relative number of individuals of that particular constitution. For example, if the ratio of one pair of allelomorphic genes (a and b) were as 3 to 5, and of another pair

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[8] Except for such deviations as are involved in the phenomenon of "non-appearance" (Danforth, Genetics, Vol. 9, pp. 198-210, 1924).

[9] W. E. Castle (Science, N. S., Vol. 514, p. 96 and p. 223) has suggested a method of estimating the number of genes when they produce a blending effect and show equal frequencies, conditions which are not often realized in human populations.

(c and d) as 4 to 6; then, reading only the first column, there should be in every $(a + b)^2 (c + d)^2$, or 6400, individuals, a^2c^2, or 144, homozygous for both a and c; $2a^2c\,d$, or 432, homozygous for a but heterozygous for c and d; and c^2d^2, or 324, homozygous for both a and d.

This form of tabulation also affords a basis for determining the theoretical frequency of different types of marriages and classes of children. Interpolation of numerical values being unnecessary until the computation has been worked through to the end, the method provides for the elaboration of a set of generalized formulae or statements of the normal expectation under varying conditions. Thus when a trait is due to the simultaneous action of two dominant genes whose incidences are as $\frac{a}{a + b}$ and $\frac{c}{c + d}$, parents, both of whom show the trait, should produce a certain number of children like themselves. In the long run the proportion of such children should be $\frac{(a + b)\ (c + d)\ (a + 3b)\ (c + 3d)}{(a + 2b)^2\ (c + 2d)^2}$ of the total number produced by such parents. Depending on the relative frequencies of the genes the value of this fraction may fall anywhere between 56 per cent and 100 per cent. Expectations from other types of matings and with other combinations of genes show a wide range of values which, while they often bear little resemblance to the familiar Mendelian ratios of animal and plant breeders, are none the less just as definite expressions of what the theory demands and are consequently of equal importance in testing the hereditary nature of a trait.

It is this difference between the expectations based on small groups with controlled matings and those for large groups with random dissemination of traits that it is desired to emphasize in this paper. The points which have been mentioned, together with others which might have been added, are more or less obvious corrolaries of the current theory of heredity, but they are nevertheless frequently ignored when the distribution of human traits is discussed. While it may readily be admitted that racial differences and their heredity are not likely to be fully explained by any one scheme, it is none the less clear that investigation of the distribution of variations in man should give adequate consideration to the special implications of the gene theory as related to human populations.

ANTHROPOMETRY OF THE LAKE WINNIPEG INDIANS

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In the Summer of 1921, while attached to an Indian Treaty Party, I availed myself of certain opportunities which presented themselves of recording some observations on the physical proportions of the adult male Indians in the neighbourhood of Lake Winnipeg.

The notes were made out of interest and for my own edification, but as I have come across so few references to articles which bear upon the physical side of the anthropology of the American Indians in Canada, (those on the Pacific Coast excepted) with which to compare these notes, they are being published now in the chance that they may be of interest to others. For permission to make these known I am indebted to Duncan C. Scott Esq., L. L. D., of the Department for Indian Affairs, Ottawa, for it is under his care that the Indians of Canada come. And, to my travelling companion Mr. Latulippe, who was the agent for the Reserves we visited, my grateful thanks are due for the help he gave me.

It seems, perhaps, a little strange that the physical anthropology of the Indians of Canada should have received so little attention; especially is this so when the work that has been done in the United States is considered. Nor is it the less strange when the Indian populations in the two Countries are compared. The population of those in the United States has fluctuated above and below the quarter of a million figure since the beginning of this century. The census for 1920, records, it is true, an increase in the population of over seven thousand since 1900, but it records a decrease of over twenty thousand since 1910. In Canada, on the other hand, according to the Annual Report for 1923 of the Department for Indian Affairs, there are in the various Reserves only two short of 106,000 Indians of all ages. They are disposed as follows:—

Alberta	8,837	Prince Edward Island	292
British Columbia	25,694	Quebec	13,366
Manitoba	11,583	Saskatchewan	10,646
New Brunswick	1,846	North West Territories	3,764
Nova Scotia	2,031	Yukon	1,528
Ontario	26,411		
Total Indian Population			105,998

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In Canada, then, the Indians number not very many less than a half of what they number in the United States; and if the belief is current that the aborigines of this Dominion are following slowly but surely along the path which the aboriginal Tasmanians trod but half a century ago, such belief is not supported by the fact that the population on the Reserves has increased by over 12,500 since 1901, and by 2,467 since the census for 1915 was taken. In this connection it may be added that over 3,000 volunteered and served with the British Forces in the War.

Now, the Indians inhabiting Manitoba are of the Algonkin Stock, and of the six Bands, with a total population of 991, with which this paper deals, those at Blood Vein, Poplar River, Berens River, Grand Rapids and Little Grand Rapids are Saulteaux (Chippewa or Ojibway) and one Band, that at Deer Lake is of the Cree Tribe (Swampy Cree or Maskegon) (1.2.3.4.) This Cree band does not speak the same tongue as the Saulteaux.

Incidentally, this Deer Lake Band has its reserved territory on the Ontario side of the border, and so it is not strictly speaking within the Province of Manitoba. The ethnology of the Saulteaux and Cree has within recent years been investigated by Skinner, who travelled amongst bands who inhabit the territory immediately to the east of that inhabited by the bands I visited. In all 167 males were examined by me. Presumably they were all at least 21 years of age, as only those of such ages are eligible for the "Treaty payment," which was being paid on this occasion. Their measurements were all taken according to the rules of the International Agreement, as set forth in Hrdlička's "Anthropometry," and were recorded on prepared blank forms. Their stature, sitting height, and span (maximum finger reach) were measured with the usual graduated rod. 1.0 c. m. was subsequently deducted from the height of those wearing mocassins: 3.0 c. m. from that of those wearing boots. All wore one or the other.

The occasion did not permit of second or corroborative readings being made. Further, not having the assistance of an interpreter, I had to rely upon signs to indicate my wishes. There are, thus, no doubt a few errors amongst the data, but it was my endeavour to avoid them, and I believe they are few.

Any information this paper contains and any deductions and comments made, are based very largely on the accompanying tables. Attention may be directed to certain points. Four of the Saulteaux Bands have their Reserves at the mouths of rivers which open into Lake Winnipeg (Blood Vein, Berens, Poplar and Grand Rapids): we may refer to them as the "Lakeside" bands. Though no two of the four Bands are by any means identical in their proportions (no doubt largely due to inbreeding for marriages amongst these Indians are largely contracted within their own particular bands) yet they resemble each other much more closely than they do the somewhat remote fifth band of Saulteaux at Little Grand Rapids. This Little Grand Rapids band in turn has proportions which are very different from the somewhat inaccessible band of Cree Indians, living at Deer Lake. As a gauge of the

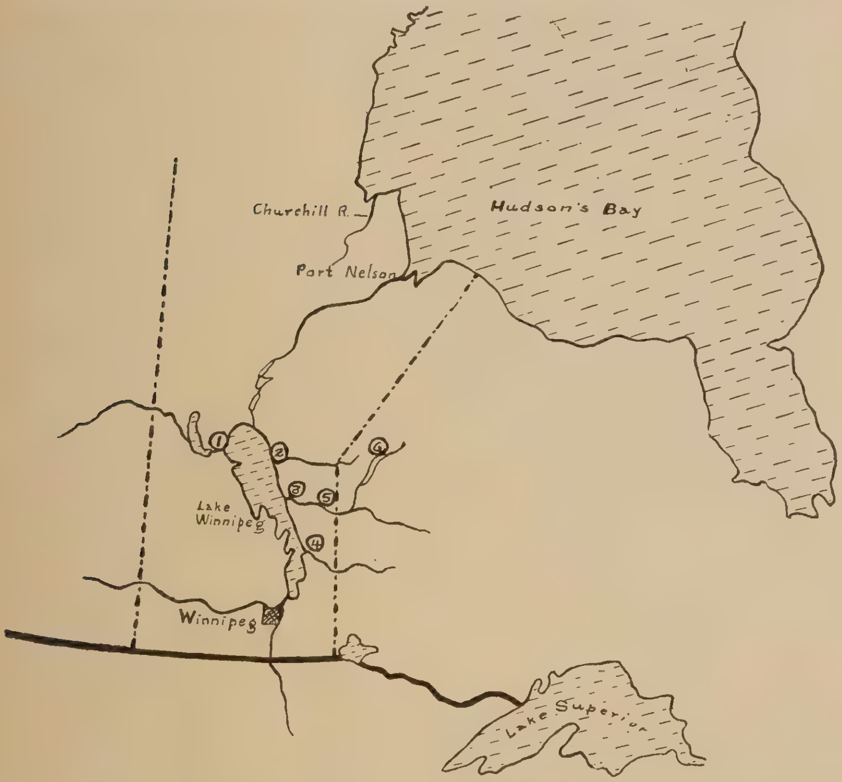

DIAGRAM OF MANITOBA
INDICATING SITES OF
INDIAN RESERVES

① Grand Rapids
② Poplar River
③ Berens River
④ Blood Vein
⑤ Little Grand Rapids
⑥ Deer Lake

distance from civilization of these two "Upstream" bands, may be offered the fact that the Deer Lake Indians had one pair of boots amongst them, (the others wore mocassins) and the Little Grand Rapids six pairs: whereas the 97 Indians living around Lake Winnipeg 52 (i. e. more than 53%) were wearing boots.

With regard to stature: a reference to the Stature Distribution Table No. 1 will show that the stature varies from an average of 167–2 c. m. at Blood Vein to 173.6 c. m. at Grand Rapids: the average for the

TABLE 1. STATURE DISTRIBUTION

	Saulteaux					Cree		
Stature in cm.	Blood Vein	Little Grand Rapids	Poplar River	Berens River	Grand Rapids	Deer Lake	Total	
154			1				1	2
155	1						1	
156	1	1					2	8
157		1					1	
158		1		1			2	
159	1	1					2	
160		1					1	
161	.	.	.	.	.	1	1	27
162	1	1	1	.	.	.	3	
163	1	.	1	4	.	3	9	
164	1	2	1	1	.	1	6	
165	1	5	1	.	.	1	8	
166	.	9	3	1	.	2	15	58
167	1	2	3	3	.	.	9	
168	2	2	1	3	.	1	9	
169	.	1	2	3	3	5	14	
170	.	3	3	2	3	.	11	
171	.	1	1	2	.	2	6	38
172	2	1	.	2	.	2	7	
173	.	1	1	4	2	3	11	
174	1	1	1	5	.	1	9	
175	.	1	1	2	1	.	5	
176	.	1	5	1	.	2	9	24
177	1	2	.	2	.	1	6	
178	.	2	.	2	1	2	7	
179		.	.	1	.	.	1	
180	.	.	.	.	.	1	1	
181	.	.	.	2	.	.	2	10
182	.	.	1	.	1	1	3	
183	1	1	.	1	1	.	4	
184	.	.	.	1	.	.	1	
No. Measured...	15	41	27	43	12	29	167	
Ave. Stature......	167.2	168.01	169.7	171.9	173.6	170.9	170.1	

whole six bands is 170.1 c. m. or 5 feet 8 inches. The 97 Saulteaux living around Lake Winnipeg have an average stature of 170.8 c. m. which is more than an inch greater than the average stature of the 41 Saulteaux at Little Grand Rapids (168.0 c.m.) though the range of stature of these two groups is practically the same (154.9–184.0 c.m.) The 29 Cree at Deer Lake have a similar average stature (170.9 c.m.) to the Lakeside Indians (170.8 c.m.), and are likewise more than an inch taller than their distant neighbours at Little Grand Rapids.

These statures are comparable with those recorded by others for members of the Algonkin stock, e. g. Chippewa (171.9 c.m.) (5) Obijway (171–172 c. m.) Cree (168.0 c.m.) The traditional enemies to the south of the Algonkin, the Sioux, (172.4 c.m.) (6) halfbreed Sioux (173. 5 c. m.) and the Iriquois (173.9 c.m.) are taller: the Shoshoni (166.1 c. m.) (7) and those in British Columbia, with an average height of about 164.5 c.m. (8), are shorter. Some Indians of the plains (10) and some of the South Western States of America and of Northern Mexico (11) are taller, others are very distinctly shorter. They range from about 158.5–174.9 c.m. By way of further comparison it may here be noted that the main stature *both* for 96,596 white men and 6,454 negroes in the United States, demobilized after the recent war, was 171.9 c.m. (12) It is consequently clear that these Indians from the neighbourhood of Lake Winnipeg have a stature which falls within the upper ranges of that for Indians in general, and that they are to be classified as tall.

In table No. 2 the excess of span (or maximum finger reach) over the stature is set out in detail. It may be seen that each hand has a considerable excess of span over stature, averaging 10.05 c. m. The result, of course, is a high average stature-span index (105.9). Those living on the lakeside have an index of over 105: those living upstream of over 106. This, of course, is remarkably high, in fact it approaches the Simian.

The mean index for 531 pure Sioux is 105.2 (6). Boas records an index of 106.7 for 34 pure Sioux. Halfbreed Sioux have a lower index (105.0): The Shoshoni 104.3 (7): Pima (103.9): whereas a few of those on the Pacific Coast rise above the 106 index. (8) This, nevertheless, is a very high index even for Indians. The mean for the white race is very constant to within a few decimal points of 102. The American Negro has an index of 105.2 (12).

Perhaps more interest centres round the sitting height and the sitting height index: (Table No. 3).

The average sitting height for the 6 bands is 88.2 c. m., which figure is almost precisely that given by Bean for American Indians in general, (88.0 c.m.) (13) The Sioux have a sitting height of 88.5 c. m., half-breed Sioux of 89.6 c. m. The Shoshoni of 86.7 c. m., Pima of 91.0 c. m. Maricopa of 87.8 c. m., Eskimo of 87.7 c. m. (13).

Western Europeans and the white population in the United States

TABLE 2.—SHOWING IN CENTIMETERS THE

(The figures below are for individual

	Bands living on the side of lake Winnipeg				The excess for 4 bands o	
Stature in c.m.	Blood Vein	Poplar River	Berens River	Grand Rapids	span over stat. in c.m	
154	.	17.	.	.	17	13.5 cm.
155	10.	.	.	.	10	
156	13.	.	.	.	13	
157	.	.	.	.	.	.
158	.	.	20	.	20	14. cm.
159	9.	.	.	.	9	
160	.	.	.	.	.	
161	.	.	.	.	.	
162	8.	10.	.	.	9	
163	12.	8.	8. 9. 6.	.	8.6	8.5 cm.
164	13.	6.	12.	.	10.3	
165	2.	10.	.	.	6	
166	.	11.10. 6.	10.	.	9.2	
167	8.	13.11. 7.	8.12.	.	9.8	
168	6. 6.	10.	8. 9.11.	.	8.3	9.2 cm.
169	.	8. 7.	10.10.10.	11. 8. 8.	9	
170	.	9. 7. 5.	17.11.	12. 6.12.	9.8	
171	.	3.	8.13.	.	8	
172	9.11.	.	12.13.	.	11.2	
173	.	9.	2. 8. 5.13.	13.10.	8.5	8.8 cm.
174	7.	11.	8. 6. 8. 9.14.	.	9	
175	.	7.	6. 8.	8.	7.2	
176	.	11.10. 9. 9. 4.	7.	.	8.3	
177	10.	.	3. 8.	.	7	
178	.	.	17.16.	6.	13	9.1 cm.
179	.	.	9.	.	9	
180	.	.	.	.	.	
181	.	.	6.10.	.	8	
182	.	16.	.	14	15.	9.5 cm.
183	4.	.	5.	13.	8	
184	.	.	6.	.	6	
Ave. excess of span over Stat.	8.56 cm.	9.1 cm.	9.88 cm.	10.2 cm.	9.5	
Ave. stature Span Index	105.1	105.4	105.7	105.8	105.5	

have an average sitting height of 90.39 c. m. (12) For the Negro in the United States it is 87.35 c. m. The Indians we are considering have, therefore, an average sitting height, which lies between that of the white and the Negro. It is 88.2 c. m. The Little Grand Rapids and Deer Lake bands it will be observed, lie at extremes in this respect, the one being 85.1 c. m. the other 91.3 c. m.

XCESS OF SPAN OVER STATURE
d also as averages.)

tature in c.m.	Little Grand Rapids	Bands living "upstream". Average excess of span over stature, in c.m.		Deer Lake	Average excess of span over stature, in centimeters	
154	.	.		.	.	
155	.	.		.	.	
156	13.	13.	9.8 cm.	.	.	
157	9.	9		.	.	
158	8.	8.		.	.	
159	11.	11		.	.	
160	8.	8.		.	.	
161	.	.	10.7 cm.	6.	6.	10.1 cm.
162	13.	13.		.	.	
163	.	.		8.13.11.	10.6	
164	10.10.	10.		14.	14.	
165	10.15. 7. 9.12.	10.6		9.	9.	
166	6.15.15. 8.13.12.13. 8.	11.2	10.9 cm.	17.12.	14.5	14.1 cm.
167	9.13.	11.		.	.	
168	9. 9.	9.		15.	15.	
169	12.	12.		15.20.11.18.15	13.8	
170	11.10.12.	11.		.	.	
171	15.	15.	9.2 cm.	18. 9.	13.5	10.6 cm.
172	8.	8.		12.10.	11.	
173	2.	2.		10. 7. 6.	7.6	
174	9.	9.		13.	13.	
175	12.	12.		.	.	
176	13.	13.	10.4 cm.	8. 3.	5.5	9.5 cm.
177	10.10.	10.		7.	7.	
178	11. 8.	9.5		17.12.	14.5	
179	.	.		.	.	
180	.	.		10.	10.	
181	.	.	10.0 cm.	.	.	5.0 cm.
182	.	.		5.	5.	
183	10.	10.		.	.	
184	.	.		.	.	
ve. excess of span over Stature	10.6 cm.			11.0 cm.		
ature span Index	106.3			106.4		

The average sitting height for the four lake bands, it will be observed on referring to table No.3 falls between that of the Little Grand Rapids and the Deer Lake bands. This applies not only to total averages, but also to the averages for almost every stature: the Little Grand Rapids almost invariably having the shortest, and the Deer Lake the greatest, sitting height with the "lakeside" bands having an intermediate sitting height. The sitting height index, is the percentage of the sitting height of the total stature, and therefore a long trunk or short legs give rise to a high index, and vice versa, a short trunk or long legs to a lower index. Primitive peoples e. g., Australians (45.5), Central Africans (47.4) and American Negroes 50.79 (12) have low indices. The Eskimo (53.7) (13) and Asiatics such as Chinese (53.6) have high indices. The white race has an index which falls between these extremes (52.5). The North American Indian has an index between that of the white and the American Negro, namely 52.0 (13). Even here there is a certain latitude, Sioux having an index of 51.4 Shoshoni (52.2) Maricopa (50.8). A few on the British Columbia coast rise above the 53.5 index (8). The average for the six bands is 51.8 and, therefore, is extremely close to that just quoted as an average for North American Indians. A similar average (51.9) is that of the four bands round the Lake. In strongly marked contrast, though, are the indices for the two "upstream" bands; that for the Little Grand Rapids band (50.5) is akin to that of the American Negro in the South, and that for the Deer Lake Band (53.4) by an equally curious coincidence is akin to that of the Eskimo in the North, and is the same as that quoted by Boas (8) for the Iriquois (53.4) their southeastern neighbours. This is somewhat remarkable;

TABLE 3. AVERAGE SITTING HEIGHT DISTRIBUTION. SUMMARY

Stature in cm.	154	156	158	160	162	164	166	168
Name of Band:—								
Blood Vein Poplar River Berens River Grand Rapids	79.0	82.0	84.5	82.0	93.25	86.95	85.0	88.5
Little Grand Rapids	—	77.0	85.7	82.2	82.5	86.0	83.3	84.3
Deer Lake	—	—	—	—	87.0	88.1	90.0	91.5

Stature in c.m.	170	172	174	176	178	180	182	184
Name of Band:—								
Blood Vein Poplar River Berens River Grand Rapids	87.56	89.08	90.3	90.4	90.8	90.0	91.8	93.5
Little Grand Rapids	85.5	87.2	88.2	87.7	89.7	—	—	89.5
Deer Lake	90.7	91.2	92.1	93.7	94.0	96.0	95.0	—

one band is Saulteaux, the other Cree. I know of no other data concerning these two tribes with which to compare these indices.

As with any group of persons who are of the same age, sex and race, some must be taller and some shorter than the average, and as the leg varies more in length than does the trunk, it follows that the shorter persons will have a greater and the taller persons a lesser sitting-height index (or relative sitting height) than the average. The average sitting-height index for white people, as we have just seen, is 52.5, but the shorter individuals may have an index of say 54.5, and the taller ones of 50.5. The average index, then, for a group of people, gives no indication of the range of the index, nor of its distribution. Bardeen (14), depending on the fact that "the relative sitting height, $\frac{\text{(100 Sitting height)}}{\text{H (total height)}}$ varies inversely as the square root of the stature, $\frac{(100\ \text{Si}\ \text{H}\tfrac{1}{3})}{\text{H}}=\text{K}$, has taken account of this, and represents the index as a constant "K". "It is an index not of build but of variation in build relative to stature." "For a given group the value is determined by its constancy." "The tallest individuals of the group should have the same index or constant as the shortest." This constant has been determined for the six bands, and from it the anticipated sitting height index has been calculated. From a comparison of the last two columns of table 4 its value with reference to the individual bands may be appreciated. Considering the relatively few figures, in any one band, with which we are dealing, together with the fact that extremes always tend to be erratic, the two columns will be seen to be not at great variance from each other.

With a millimeter rule measurements were taken of the width of the nose, and of the length of the mouth and upper lip: and with sliding compasses the length and breadth of the ear and of the hand were measured. It was found to be more convenient to measure the right hand in preference to the left, but according to custom the left ear was selected. As the details of these are hardly worth enumerating here, only their averages are recorded. They are to be found at the end of the paper in the table of summaries.

The width of the nose for those of Blood Vein and of little Grand Rapids was not taken, the others (97 observations) have an average width of 40.8 mm. This appears to be a medium width for Indians, being less than that for the Shoshoni (43.4 mm.), the Chippewa (42.8 mm.) and the Maricopa (41.4 mm.), and greater than that for the pure

TABLE NO. 4

Stature in cm.	Sitting height in cm. of each individual	Ave. sitting height	Ave. S. H. Index	Calculated rel. sitt. ht. (Bardeen)
	Blood Vein			k = 291.0
154				
156	84.5 79.5	82.	52.73	54.0
158				
160	82.	82.	51.41	53.65
162	85.	85.	52.62	53.43
164	87 86.5	86.7	53.02	53.21
166	91.	91.	54.99	53.01
168	92.5 87.87.	88.8	53.01	52.79
170				
172	91.5	91.5	53.35	52.37
174	92.5	92.5	53.31	52.16
176				
178	90.5	90.5	50.98	51.77
180				
182				
184	89.5 99.5	94.5	51.49	51.20
Averages for the Band		88.3	52.8	
	Popar River			k = 284.15
154	79.	79.	51.46	53.06
156				
158				
160				
162	81.5	81.5	50.46	52.18
164	85.87.	86.	52.59	51.96
166	82.5 84.5 87. 80.	83.5	50.45	51.75
168	85.5 85. 90.5 87.	87.	51.9	51.55
170	88.84.86.87.88.	86.6	51.09	51.34
172	84.	84.	48.97	51.14
174	89.5 92.5	91.	52.45	50.94
176	91.90.91. 89.5 91 91.5	90.6	51.62	50.75
178				
180				
182	89.	89.	49.03	50.19
184				
Averages for the Band		87.1	51.3	

TABLE NO. 4—*Continued*

Berens River

Stature in cm.	Sitting height in cm. of each individual	Ave. sitt. height	Ave. S. H. Index	Calculated relative sitt. ht. (Bardeen) k =289.5
154				
156				
158	84.5	84.5	53.01	53.61
160				
162				
164	84.5 86.5 89.5 89 87.5	87.4	53.46	52.94
166	84.5	84.5	51.05	52.73
168	91. 88. 91.5 90.5 86.5 88.	89.25	53.28	52.52
170	89. 87.5 86. 89.5 88.	88.	51.91	52.31
172	91.90.91.87	89.75	52.33	52.11
174	88.5 93. 92. 89.5 89.5 89 91.5 90 87	90.	51.87	51.91
176	88.5 90.5 92.	90.3	51.45	51.71
178	88. 92.5 89.5 92.5	90.6	51.04	51.51
180	90.	90.	50.14	51.32
182	94.5 92.	93.25	51.37	51.13
184	96. 92.5	94.25	51.36	50.94
Averages for the Band......		89.5	52.0	

Grand Rapids

Stature in cm.	Sitting height in cm. of each individual	Ave. sitt. height	Ave. S. H. Index	k =287.3
154				
156				
158				
160				
162				
164				
166				
168				
170	90.87.91.87.85.88.	88.	51.91	51.91
172				
174	91.89.	90.	51.87	51.51
176	89.	89.	50.77	51.31
178	92.	92.	51.82	51.12
180				
182	92.	92.	50.69	50.74
184	90.	90.	49.04	50.55
Averages for the Band...........................		89.4	51.5	

TABLE NO. 4—*Concluded*

Stature in cm.	Little Grand Rapids Sitting height in cm. of each individual	Average sitt. ht.	Ave. S. H. Index	Calculated rel. sitt. height (Bardeen) k =279.5
154				
156	77.	77.	49.51	51.98
158	85.5 86.	85.75	54.44	51.76
160	81.5 83.	82.25	51.72	51.54
162	82.5	82.5	51.08	51.33
164	84.5 87.5 84.5 83.5 74. 84.5 86.	86.	52.59	51.11
166	83. 86.5 83. 83.5 75.5 87. 86.5 84.5 85.	83.36	50.36	50.91
168	82.84.84. 87.5	84.37	50.37	50.71
170	87.88. 84.5 82.5	85.5	50.44	50.50
172	86.5 88.	87.25	50.87	50.31
174	87. 89.5	88.25	50.86	50.11
176	90. 85.5	87.75	50.0	49.02
178	88.5 90.5 91. 89.	89.75	50.56	49.73
180				
182				
184	89.5	89.5	48.77	49.19
Averages for the Band		85.1	50.6	

	Deer Lake			k =296.5
154				
156				
158				
160				
162	87	87.	53.87	54.44
164	89.85.89. 89.5	88.1	53.88	54.22
166	90.5 90.5 89.	90.	54.4	54.0
168	91.5	91.5	54.6	53.78
170	88.5 90.5 91.5 93. 90.	90.7	53.5	53.57
172	93.90.89.93.	91.25	53.2	53.36
174	91.92.93. 92.5	92.1	53.1	53.16
176	93.5 94.	93.7	53.39	52.95
178	93.5 95. 93.5	94.0	52.9	52.75
180	96.	96.0	53.5	52.56
182	95.	95.0	52.3	52.36
184				
Averages for the Band		91.3	53.4	

Sioux (39.9 mm.), the Indians of British Columbia (39.5 mm.), and for the Pima Indians (39.0 mm.).

The length of the mouth (62.6 mm.) is almost identical with that for the Chippewa (62.7 mm.), the only tribe of which measurements are at hand with which to compare it.

It is well known that the Indians have large mouths and broad nostrils, or at least that their dimensions are intermediate between those of the white and the negro. Hrdlička's 100 Old White Americans, (15) who were descended from the earlier white immigrants to the United States, may be taken as a sample of the white race. Their mouths (53.0 mm.) are shorter by approximately 10.0 mm., and their noses (36.0 mm.) are narrower by approximately 5.0 mm. than those of the Lake Winnipeg Indians: in the same manner half breed Siouz have noses (37.6 mm.) which are 2.3 mm. narrower than those of the full-blooded Sioux. Nor is there much to be said on the upper lips. These were measured from the septum of the nose to the red of the lip. The Cree band (Deer Lake) and the Little Grand Rapids band have similar average lengths (17.4 mm. and 17.7 mm.) respectively, these lengths being from 1.0 to 2.0 mm. shorter than the lips of those on the lake side.

The hand-breadths when plotted out against the hand lengths cover the graph paper more or less indiscriminately, thus showing that hands of all lengths and breadths are to be met with amongst the various bands. Their averages and their indices are recorded, for what they are worth, in table No. 7. I know of no Indian measurements with which to compare them. It is, however, stated that the Indians of the North have narrower hands than have those of the South and that Indians on the whole have narrow hands. The hands of all but the Blood Vein band were measured: 151 altogether.

In all 104 ears were measured, their average dimensions being, 66.4 mm. long, and 35.0 mm. broad. The Shoshoni have ears of practically the same length (65.2 mm.). The Chippewa measured by Hrdlička, on the other hand, had larger ears (both longer and broader). Their dimensions were 72.0 mm. long and 38.8 mm. broad. These Chippewa were at or past middle life and would accordingly tend to have longer ears than when they were younger. It may be worth noting that the two bands who are remote from the lakeside have the shortest but broadest ears, and therefore the ears with the highest indices, see table No. 7.

Attention was also paid to the digital formula, to the colour of the iris and to the shape of the bridge of the nose. With regard to the digital formula it may be recalled that amongst monkeys, apes and most human beings, and in fact, even amongst such primitive pentadactyl animals as the water turtle, the middle finger is the longest finger, the ring is the next longest, and the index, the little finger and the thumb follow in that order. This may be represented graphically thus. . . . . 3 ⟩4 ⟩2 ⟩5 ⟩ thumb. In about fifty percent of white people the index equals the ring finger in length, and in about ten percent it exceeds it. The formula expressing these conditions would read thus—3 ⟩2 ⟩= 4 ⟩5 ⟩ thumb and 3 ⟩2 ⟩4 ⟩5 ⟩ thumb. To have an index longer than a fourth (ring) finger is a peculiarly human trait. (15, 16, 17) Negroes rarely have other than the primitive formula. The Indians of each of the five bands which were examined for this point, all conformed to the primitive type, in that the index was shorter than the fourth finger in every case. The interest in this matter lies in the fact that though the brain exercises a remarkable control over the five fingers of our hands, the hands and the fingers themselves are astonishingly elementary in structure and presumably on that account they are plastic structures, and with us, the white race, it would appear that the index is evolving into the second longest of our digits, and so is deposing the fourth or ring finger from that position. Apparently this is not yet the case with the Indian. The relative lengths of the index and ring fingers is to be gauged by comparing the levels of their tips with reference to the root of the nail of the middle finger. This was done for the right hands of all but the Poplar River band; that is to say 140 observations in all were made.

TABLE 5.—DISTRIBUTION OF THE COLOUR OF THE IRIS
(recorded in percentages.)

	No. examined	Black or Dark Brown	Medium Brown	Light Brown	Grey or Blue Grey
Blood Vein.	15	53.3%	40.0%	6.7%	——
Poplar River.	27	70.4%	22.2%	7.4%	——
Berens River.	43	46.5%	27.9%	13.9%	11.6%
Grand Rapids.	12	33.3%	33.3%	33.3%	——
Total for the above 4 bands.	97	52.6%	28.8%	13.4%	5.2%
Little Grand Rapids.	32	100.0%	——	——	——
Deer Lake.	10	100.0%	——	——	——
Chippewa (Hrdlička).	17	100.0%	——	——	——
Sioux (pure) (Sullivan).	539	97.3%	——	1.3%	1.7%
Sioux (half blood) (Sullivan)	77	68.8%	——	18.2%	13.0%

The colour of the iris was scored off on the blank forms under one of four headings—viz. black to dark brown, medium dark brown, light brown, and grey or blue grey; 100% of the upstream bands (Little Grand Rapids and Deer Lake) had dark brown to black eyes. Of those living on the lake side only 52.6% had eyes of this dark hue. Of Hrdlička's fullblooded Chippewa, 100%, and of Sullivan's fullblooded Sioux all but 3% had very dark eyes. Of his halfbloods, on the other hand, 31.2% had lighter coloured eyes. The question arises as to the value of the colour of the iris as a criterion of mixed blood. Even albinism, of course, may occur amongst Indians, but can any, or at most, more than a very small percentage of pure Indians have irises of lighter shades than dark brown? Certainly we find that the less accessible bands have a hundred percent dark eyes, whereas the more accessible ones on the water front have only a little more than fifty per cent dark eyes.

The same question may be put concerning the value of the shape of the bridge of the nose, at least so far as the Algonkin stock is concerned. Noses of all shapes are to be found, it is true, but it will be noted on referring to table 6 that the Cree (Deer Lake), and the Chippewa who were selected on account of their known purity, correspond very closely in the percentage distribution of the shape of the nose, and each has one hundred per cent dark eyes. This may very easily be a mere coincidence, but it is worth remarking, especially as the four bands on the Lakeside have different percentage distributions both of nose form and also of eye colour; a distribution suggesting impurity.

TABLE 6—DISTRIBUTION OF THE SHAPE OF THE BRIDGE OF THE NOSE

(Recorded in percentages.)

	No examined	Straight	Convex	Concave	Concavo-convex
Blood Vein	15	20.0%	20.0%	6.7%	53.0%
Poplar River	27	14.8%	70.4%	3.7%	11.1%
Berens River	41	29.3%	19.5%	31.7%	19.5%
Grand Rapids	12	25.0%	41.6%	——	33.3%
Total for the above 4 bands.	95	23.2%	36.8%	15.8%	24.2%
Deer Lake	29	17.2%	48.3%	20.7%	13.8%
Chippewa (Hrdlička)	17	12.0%	52.0%	18.0%	17.0%

Amongst the Indians of the Plains the proportion of fullbloodedness is on an average 70%: for example, the Iowa are only 24.2% pure, the Assiniboine 63.3%, the Shoshoni 86.7%, and the Cheyenne 87.1%. In many of the tribes of the South Western States of America the amount of mixed blood is insignificant (11). It is certain that there is a fair amount of white blood amongst the six bands with which this paper deals: those around the Lake would naturally have the greatest opportunity of being mixed. The bizygomatic biparietal index, of which much use has already been made, as in the pure Indian it does not fall below 94, and in the white does not rise above 91, whereas in the half-breed it tends to lie between these figures would be perhaps the best means of settling this question, as has been done in the United States. (19)

In conclusion:—This paper is intended to be a record of the stature, span, sitting height, hand index, digital formula and of certain facial features of the Indians living at the present time on the Reserves in the neighbourhood of Lake Winnipeg. All are of the Algonkin stock, five bands are Saulteaux, and one is Swampy Cree. None of the bands is pure Indian, but the stature-span index, the colour of the iris, the shape of the nose, the index of the ear, and the length of the upper lip tend to distinguish the four bands on the side of Lake Winnipeg from the

TABLE 7. SUMMARY OF AVERAGES

		Number Examined	Stature in c. m.	Span in c. m.	Span over Stature in c. m.	Index of Span	Sitting Height in c. m.	Index of Sitting Height	Constant
Lakeside	Blood Vein	15	167.2	175.8	8.6	105.1	88.3	52.8	291.0
	Poplar River	27	169.7	178.8	9.1	105.4	87.1	51.3	284.1
	Berens River	43	171.9	181.8	9.9	105.7	89.5	52.0	289.5
	Grand Rapids	12	173.6	183.8	10.2	105.8	89.4	51.5	287.3
Ave. for above 4 bands		97	170.8	180.3	9.5	105.5	88.7	51.9	288.1
Upstream	Little Grand Rapids	41	168.0	178.6	10.6	106.3	85.1	50.6	279.5
	Deer Lake	29	170.9	181.9	11.0	106.4	91.3	53.4	296.5
Ave. for above 6 bands		167	170.1	180.15	10.05	105.9	88.2	51.8	287.3

		(97 obs.)	(150 obs.)	(133 obs.)	Hand (151 obs.)			Ear (104 obs.)		
		Width of Nose	Length of Mouth	Length of Upper Lip	Length	Breadth	Index	Length	Breadth	Index
Lakeside	Blood Vein	—	—	—	—	—	—	—	—	—
	Poplar River	3.96	6.3	1.83	19.1	8.53	44.7	6.9	3.5	50.7
	Berens River	4.09	6.4	1.95	19.2	8.69	45.3	6.85	3.46	50.5
	Grand Rapids	4.19	5.9	1.83	19.0	8.56	45.1	6.93	3.3	47.6
Ave. for above 4 bands		4.08	6.3	1.89	19.2	8.6	45.0	6.88	3.4	50.1
Upstream	Little Grand Rapids	—	6.13	1.77	18.6	8.44	45.4	6.07	3.6	59.3
	Deer Lake	4.08	6.25	1.74	19.2	8.48	44.2	6.25	3.6	57.6
Ave. for above 6 bands		4.08	6.26	1.86	19.0	8.55	45.0	6.64	3.5	52.7

two bands living further from the more usual track of the white man. It is suggested that these two bands are purer blooded. It is somewhat remarkable that, though having characteristics in common, these two presumably purer bands—one a Saulteaux, the other a Cree—differ from each other by more than an inch in stature, but much more noteworthy is their difference in sitting height, and sitting height index.

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METOPISM AS FOUND IN FILIPINO SKULLS[1]

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The metopic suture, as well known, is an anomaly formed by the non-union of the two lateral halves of the frontal bone along the midline of the forehead. This bone develops from two centres of ossification marked later by the two tubera frontalia. Normally the suture between the two resulting frontals begins to obliterate during the last quarter of the first year after birth and then gradually closes until the two bones have fused completely which occurs not later than the fourth to sixth year of life.

In some individuals, however, the two frontals fail to fuse, giving rise to what is known as "metopism" or a persistent metopic suture. The extent of this suture is quite variable; it may be continuous from the nasion to bregma or there may remain merely unossified portions at the upper, middle or lower parts of its course. At times short vertical or transverse sutures are found located at a level somewhat inferior to the plane of the two frontal tuberosities, and such sutures have always been interpreted as remnants of the metopic fontanelle.

The metopic fontanelle is taken to be a deficiency in the halves of the frontal bone below the level of the frontal tuberosities or along the lower third of the suture. We owe to Gerdy and Schwalbe the first account of its occurrence. In some instances, remnants of this fontanelle are found in adult skulls in the form of the already mentioned short independent sutures which may be accompanied by a fontanelle bone or by short transverse irregular fissures in the lower midline of the frontal, even after the metopic suture itself has ossified.

The present report is based on the study of the incidence of "metopism" (suture and fontanelle) in Filipino skulls. The material utilized was that from the collection of the Department of Anatomy, University of the Philippines and totalled 619 skulls of subjects above six years of age. The majority of the skulls were those of adults. No specimens of individuals under six years of age were noted, this being the period above which the metopic suture or fontanelle should be completely closed.

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[1] Read before the Annual Meeting of the Philippine Islands Medical Association, Dec. 18, 1923.

The author will not endeavor to advance any conclusions in this paper because the measurements of the skull collection at the time of writing this were still unfinished, and only 100 measured skulls could be used as control for basis of comparison.

Consistent with this idea, it is desired to limit the scope of the paper to a mere report of the frequency of metopism in Filipino skulls, and to a comparative study of the different characteristics connected with the anomaly as observed by the writer and the various authors who have reported on the subject before.

Frequency—Out of the 619 skulls of our collection, 12 show undoubted metopic suture and 2 remnants of metopic fontanelles. The percentage of metopism is thus close to 2.2 per cent. The details are shown in the following table:

TABLE SHOWING THE RESULT OF THE VARIOUS MEASUREMENTS MADE IN THE FOURTEEN SKULLS

Nationality	Sex	Age	Cephalic Index	Small frontal Width	Interorbital Width	Interorbital Index	Cranial Capacity	Remarks
		Years		*mm*	*mm.*		*cc*	
Filipino	m	30	80.9	93.5	24.5	25.4	1390	metopic suture complete
"	m	25	76.9	97.0	28.5	28.9	1340	" " "
"	m	52	80.0	83.5	21.6	23.8	1250	" " "
"	m	28	76.5	90.0	25.7	26.4	1365	" " "
"	f	96	77.9	101.0	27.5	27.4	1200	" " "
"	m	33	79.5	101.0	25.5	26.1	1345	" " "
"	m	49	75.7	97.0	25.6	26.9	1570	" " "
"	m	20	82.8	85.9	24.0	25.9	1320	" " "
"	f	33	77.4	97.0	28.5	29.4	1360	" " "
"	m	32	77.1	93.1	27.8	27.2	1465	" " "
"	m	40	80.8	104.3	28.2	27.9	1320	" " "
"	m	41	75.0	95.4	27.4	26.9	1460	" " "
"	m	49	86.1	97.7	23.5	23.3	1290	with remnant of metopic fontanelle
"	m	30	70.8	92.4	23.8	25.0	1280	" " " "

The frequency of metopisms in different races and nationalities reported up to the present, have led some anthropologists to connect the feature with the degree of development of the frontal lobes of the brain and an intellectual advancement. While the anatomical basis for such beliefs may not be very clear, yet the incidence of the anomaly in the various human groups where it was studied is suggestive. Thus Martin, in his Manual of Anthropology, has assembled the following data on the frequency of metopism:

Australians	1.0 per cent	Alsatians	5.5 per cent
Negroes	1.2 “ ”	Bavarians	6.4 “ ”
Malayans	2.8 “ ”	Swiss	7.1 “ ”
Papuans	4.3 “ ”	Hamburgers	9.5 “ ”
Slavs	6.4 “ ”	Scotchmen	9.5 “ ”
Parisians	9.7 per cent		

To which may be added Anoutchin's table in Topinard's “Éléments d'Anthropologie:”

Europeans	8.7 p.c. (10,000)	Malays	1.9 p.c. (892)
Mongols	5.1 “ (621)	Negroes	1.2 “ (959)
Melanesians	3.4 “ (698)	Australians	1.0 “ (199)

In our series the percentage of metopism conforms closely with the figures given for Malays, under which race the Filipinos are classified as a group. There were also in our collection 6 other skulls showing traces of the medio-frontal suture at its nasal extremity, which if added to the 14 skulls under study would throw our percentage to about 3.2 per cent, but which we refrained from doing, believing that the condition is of common occurrence even in otherwise normal skulls.

As to the frequency of metopism in the two sexes, Schultz, in his review of the literature on metopic fontanelle, found that so far the latter anomaly was encountered in 21 males and in 3 females.

In our series we found metopic suture in 10 males and 2 females; and the two cases of remnants of metopic fontanelle were both in males. These figures so far as they go would seem to support those quoted by Schultz, but it should be noted that our collection of skulls having been obtained mostly from the Bilibid Penitentiary includes a much greater proportion of males than females, for which reason a definite conclusion as to the frequency of metopism in the Filipinos would hardly be justified.

In search of the literature on the subject, the writer failed to find any account of the relation of the anomaly to age in adults. Schwalbe found the frequency of the metopic fontanelle in children up to 1.5 years of age to be 15.2 per cent. All but two of our cases were found in individuals between the ages of 20–50 years. The cases are as follows:

20–29 years	3	60–69 years	0
30–39 “	5	70–79 “	0
40–49 “	4	80–89 “	0
50–59 “	1	90–99 “	1

Relation to Cephalic Index, Inter Orbital Index and Cranial Capacity.—Calmette states that metopism is more frequently encountered in brachycephalic than in dolichocephalic skulls, but if such were always true we should expect to find a higher percentage of incidence than is actually encountered in the Filipinos, whose cephalic index in 70 of our 100 cases was over 80. The cephalic index in our 14 metopic crania varied from 70.8 to 86.1, with an average of 78.3. From the table it will be seen that only 5 cases were brachycephalic denoting an incidence of 35 per cent of skulls with cephalic index above 80.0. The majority of our cases were found in mesaticephalic skulls.

Many writers, among them Bolk, Welcker and Papillault make the statement that metopism is usually found in skulls showing a wider forehead than the average of the group studied. While this contention seems at first sight very reasonable, yet the study of our cases and of our control material does not seem to sustain it for the Filipinos. From measurements of the smallest frontal width on our 100 normal skulls, we obtained a minimum width of 7.81, a maximum of 10.43, with an average of 9.4 cm.; while the same measurement of the metopic cases showed a minimum of 8.35, a maximum of 10.43 and an average of 9.49 cm. thus giving but slight differences in favor of the metopics. It could be noticed however, that in 8 of our cases the diameter frontal minimum was greater than either of the above averages.

Schwalbe, David, Fischer and Schultz also observed in metopic cases an increase in the interorbital width and index. Our findings agree. The average measurement of the interorbital width in the 100 control crania was 2.35, that in the metopic cases 2.58 cm.; the average interorbital index in the control cases was 2.41, in the metopic 2.64. These averages as compared with those of Schwalbe, which were 2.94 cm. for the interorbital width and 2.81 for the index, using European skulls, appear as one would expect a trifle smaller.

The other factor often encountered with this anomaly is a larger than average cranial capacity, although Fischer reported metopism in the skulls of two idiots, one of them microcephalic.

In measuring the capacity of our skulls, both shot and mustard seed were employed, and the combined average volumetric readings in each case were recorded. The procedure was the ordinary method recommended by Hrdlička and others, of filling the skull as full as it could possibly hold, using uniformity of techinque. The volume found for the 14 skulls varied from 1200 to 1570 cc. distributed as follows: Four were between 1200 to 1290 cc., seven between 1320 to 1390 cc., two 1460 and

1465 cc. respectively, while the last skull recorded a capacity of 1570 cc., the average being 1354 cc. Our control of 100 skulls on the one hand gave a minimum of 1105, a maximum of 1702.5 and an average of 1401.1 cc.

Eleven of the metopic specimens did not reach the average of the control series and only three exceeded this average. One of the latter was markedly megalocephalic (1570 c.c.)

Description of the Anomaly.—As previously stated, every one of the first twelve skulls in the table showed a complete metopic suture in the median-fronted line from nasion to bregma. The sutures remained prominent, though in general their interlocking margins were less serrated than and not so irregular as in other sutures, this being especially notable in the inferior halves (Pl. I, Fig. 1). All of the twelve cases, however, preserved the features of a true suture. The axis of the suture in ten of the cases swerved to the right of the sagittal suture as the two were to meet at the bregma and only in the remaining two skulls were they found to be directly in line.

On the other hand, the internal aspect of the suture did not show the irregular serrated interlocking margins, and was found instead more or less in the form of a double linear ridge with a very narrow groove in the middle. This condition was encountered in nine of our cases, while in the other three the suture was completely obliterated on the inside in two and partially so in the third case (Pl. I, Fig. 2).

The last two skulls in the table, with remnants of metopic fontanelle, deserve to be described individually. The first (Pl. II, Fig. 3) was from a male Filipino, 49 years old. It weighed 451.0 gms without the mandible. Its maximum width was 14.53, its maximum length 16.87 cm., giving a cephalic index of 86.1. The small frontal diameter measured 9.77 cm. showing a relatively wider forehead than the average skull in the series of control. The cranial capacity, however, did not reach the mean of the control series, showing only 1290 cc.

The abnormal frontal suture was located about the mid-vertical line, below the plane of the two frontal tuberosities. Its lowermost point was 2.2 cm. above the nasion, irregular in outline and roughly assuming the form of the Arabic numeral "7." It had a vertical limb 6.8 mm. long and a shorter transverse arm of about 4 mm. in length, the two forming an angle at the left of the median line. The vertical limb was in line with a remnant of the metopic suture extending from the nasion to a point 1.45 cm. above. But these sutures were not continuous with each other. On the inside the suture appeared to be represented by two parallel grooves about 2.0 cm. long, running vertically and communicating with the two limbs of the suture outside. Intervening between these two grooves was a low ridge, which converged downwards to the internal frontal crest with the two lateral boundaries of the two grooves. The distance from the lower point of the grooves above to the foramen caecum below was 2.24 cm. (Pl. II, Fig. 4).

The second skull (Pl. III, Fig. 5) was also from a male Filipino, 30 years of age, with exceptionally thick bones and weighing 738.0 gms. without the mandible. Its greatest width measured 13.14, its greatest length 18.54 cm. giving a cephalic index of 70.8. The diameter frontal minimum was 9.24 cm. and the interorbital breadth 2.38 cm. giving an interorbital index of 25.0. The volume of the cranial cavity was only 1280 cc., or very perceptibly lower than the average. The abnormal suture on the frontal was found located 2.3 cm. above the nasion, approximately in the middle between the latter point and the plane of the two frontal tuberosities. Its main axis ran transversely and formed a figure approaching an inverted "s" placed horizontally. The accompanying picture shows the suture quite well. The longest transverse length of the suture measured about 9 mm. A little below the main suture was another short independent groove about 2 mm. long which would bisect the median line of the former if prolonged upwards. On the inside, the suture showed also two grooves somewhat similar to those of the first case (as seen in Fig. 6, Pl. III). These grooves were 1.1 cm. in length and separated by a low median crest, which converged downwards into the superior end of the internal frontal crest. The distance between the two hardly exceeded 2 mm. while their inferior endings were 1.7 cm. above the foramen caecum.

Discussion.—Anatomical explanations offered for the origin of the metopic fontanelle are quite varied. Some investigators, among them Schultz, consider it originally as an anterior prolongation of the bregmatic fontanelle, a part of which has become constricted and isolated from the rest during ossification. He based this contention on his findings among 35 infantile skulls of a few months of age, in six of which he found the anterior fontanelle prolonged to within 1.0 to 1.7 cm. of the nasion.

Others interpret the fontanelle as a divergence of the lines of ossification of the two frontal tuberosities, while Maggi looks upon it as a product of the approximation of four frontalia media, basing this assumption upon his isolated anatomical observations. Zanotti gave another explanation, considering the fontanelle as the last trace of the foramen which corresponds to the location of the paraphysis of the primitive vertebrates.

By Schwalbe a persistent metopic fontanelle was attributed to "some progressive variation which bears a relation to the greater development of the frontal lobe of the cerebrum."

Martin explains the persistence of the metopic suture as "the effect of considerable growth of the frontal cerebrum as occurring in some brachycephalic groups, which growth exerting internal pressure prevents the normal concrescence of the frontal bone, as also occurs in hydrocephalic skulls in which regularly the metopic suture persists."

Rauber offered a different explanation by considering its persistence as influenced by the site of the anterior neuropore of the medullary canal of vertebrates, which may under special circumstances exert its influence on the ossification of the skull. The greater percentage of incidence of the suture among the more highly civilized races finally gave rise with some authors to the view that the metopic suture is the product of a strongly developed brain and that it is one of the signs of racial superiority.

Summary and Conclusions.— Summarizing our findings, we can tentatively state that:

1. The incidence of metopism in our series falls within the figures given by other observers for the Malay peoples.
2. Our observations tend to confirm the greater frequency of this anomaly in the males.
3. The anomaly was most frequently encountered in the Filipino skulls of the ages between 20 and 50.
4. Of the Filipino skulls in which metopism was encountered the largest proportion (57 per cent) were mesocephalic, 36 per cent were brachycephalic and only one or 7 per cent was dolichocephalic.
5. Measurements of the diameter frontal minimum tend to confirm the findings of others who claim that metopism is associated with broader forehead.
6. The contention that the inetrorbital width and index are greater in metopic skulls, finds confirmation in our observations.
7. Regarding the notion that metopism is generally associated with a greater skull capacity, it may be stated that 11 out of our 14 metopic skulls showed an average capacity below that found in the control series of 100.
8. As with other cranial articulations so in the obliteration of the metopic suture the soldering on the inner table is observed ahead of that

in the outer. If the suture persists after the sixth year, it usually remains open throughout life, or at least up to 50.

In conclusion the writer would like to remark that in so far as the incidence of frequency and its relation to sexes and cranial capacity, it would be unfair with our present material to make our tentative conclusions (Nos. 2 and 7) as final, because most of our skulls were taken from a penitentiary population where naturally the degree of mental development may be assumed to be below the standard, and that moreover the percentage of males was decidedly in the majority. To draw fair conclusions on these points we should have a collection obtained from more heterogeneous and more representative sources.

With reference to the matter of etiological theories, the writer with his present observations is hesitant to associate himself with any one of the theories so far advanced as explaining the causation of the anomaly; yet personally he inclines to the theories advocated by Schwalbe and Schultz as offering the most reasonable premises for accounting for the condition.

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PLATE I

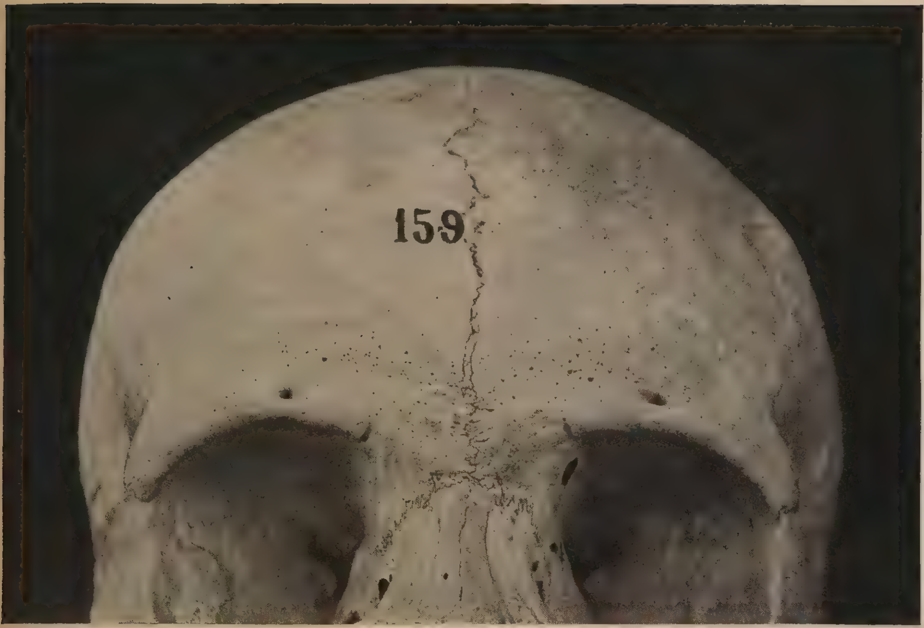

FIG. 1. Front view of skull illustrating the group showing complete metopic suture.

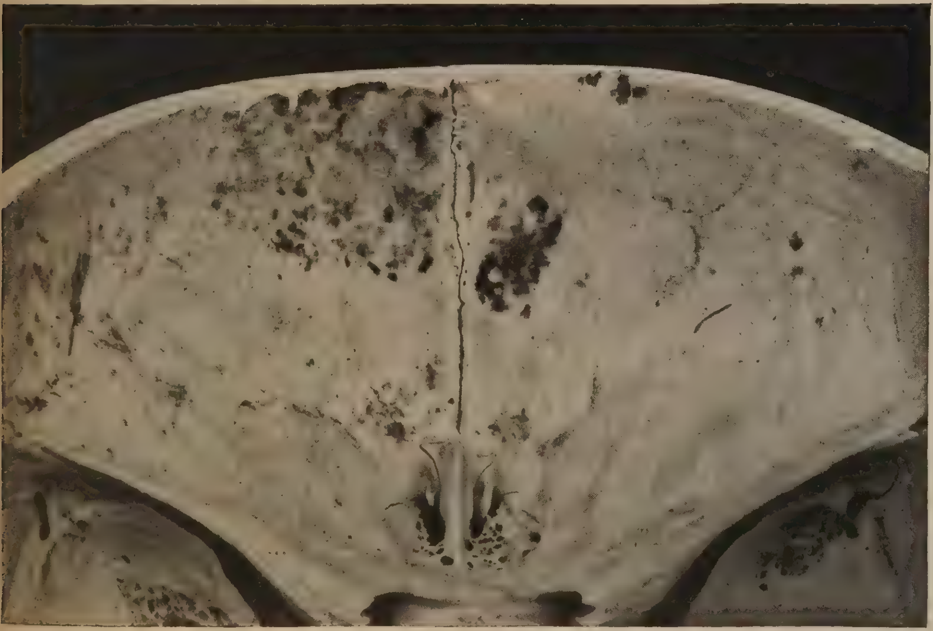

FIG. 2. Same skull with upper part sawed off showing inside appearance of suture.

PLATE II

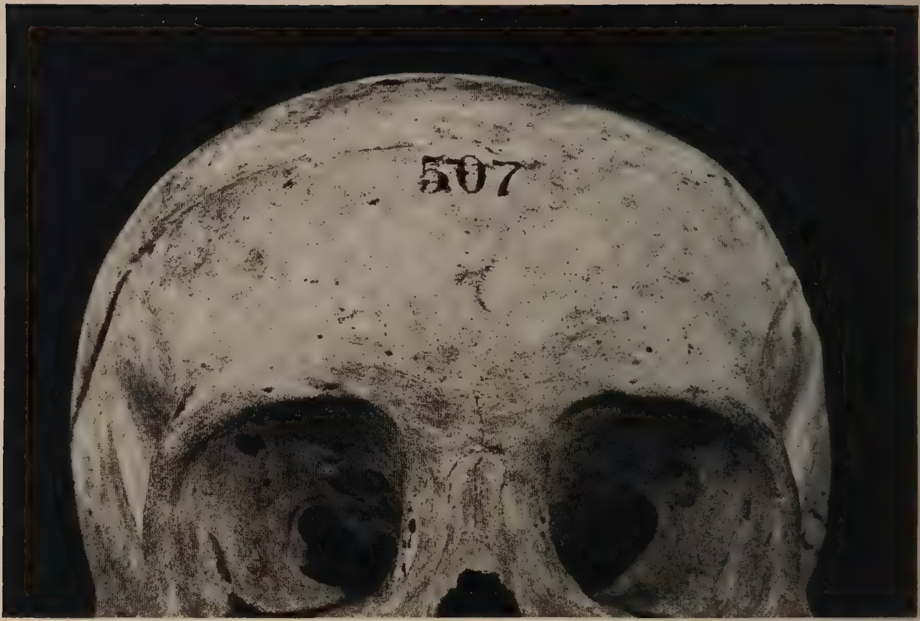

FIG. 3. First skull showing remnant of metopic fontanelle.

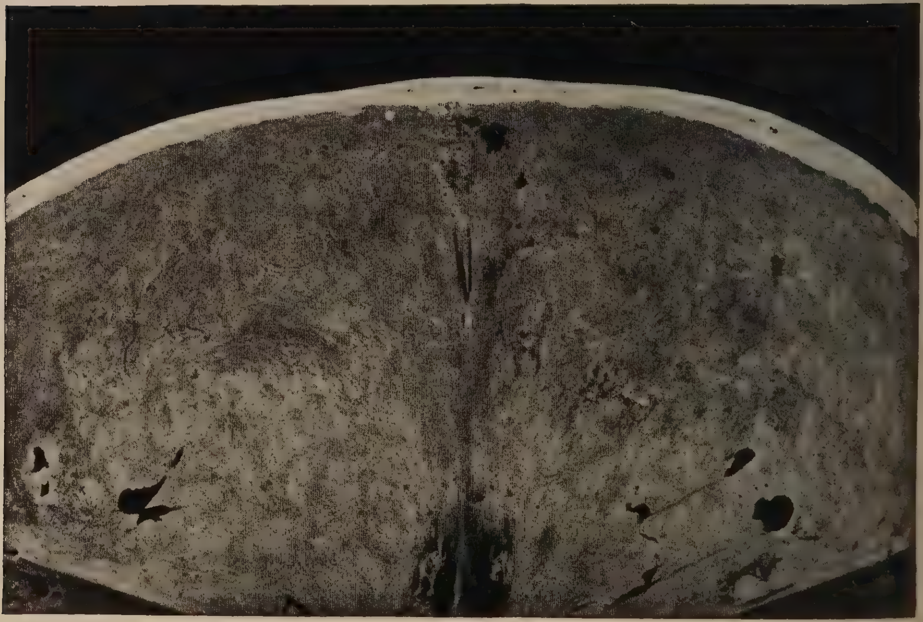

FIG. 4. Same skull, inside view of abnormal suture.

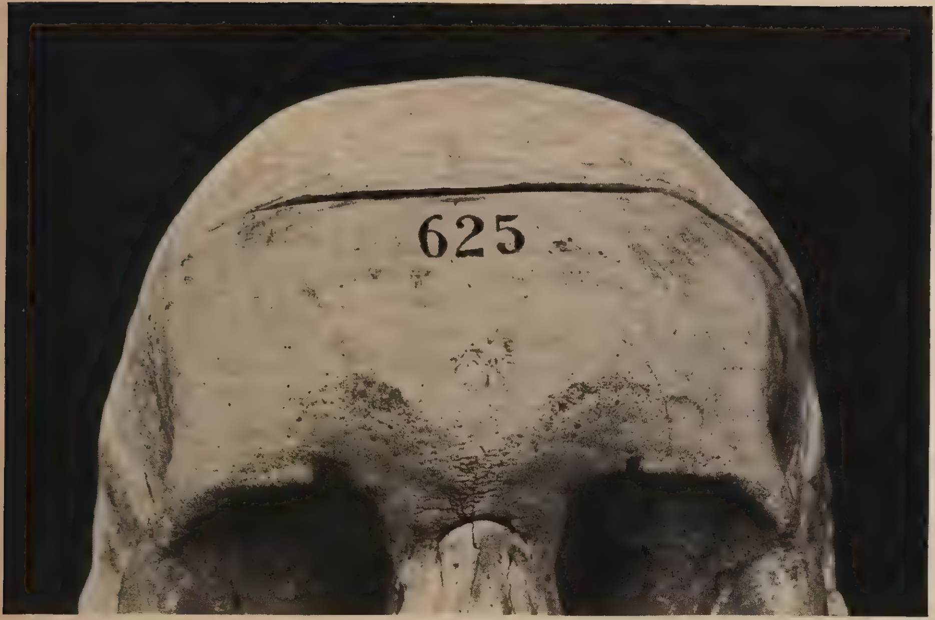

FIG. 5. Second skull showing remnant of metopic fontanelle.

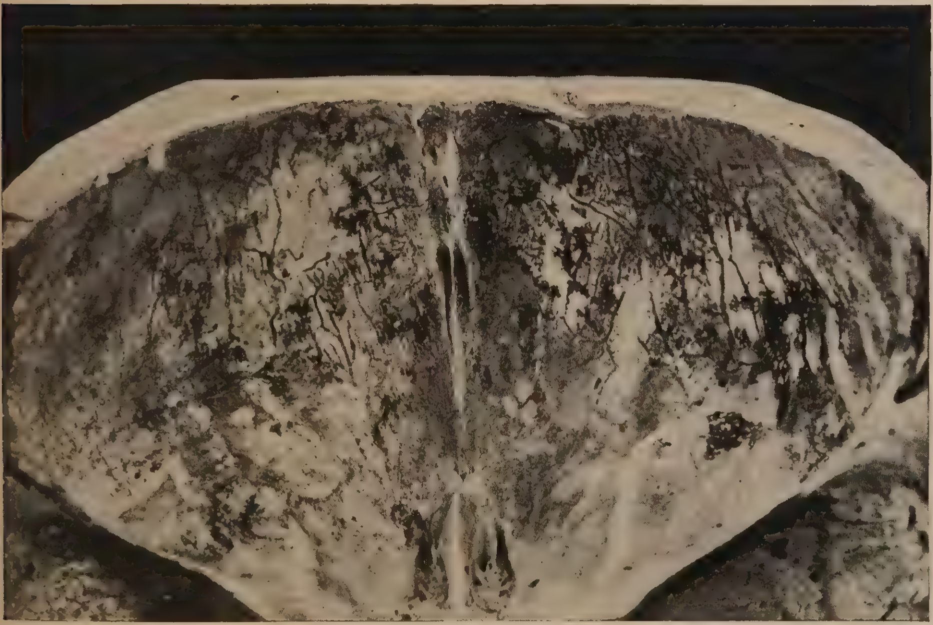

FIG. 6. Same skull, showing inside view of suture.

ENDOCRANIAL SUTURE CLOSURE

ITS PROGRESS AND AGE RELATIONSHIP

PART I.—ADULT MALES OF WHITE STOCK

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AM. J. PHYS. ANTHROP., 1924., Vol. VII., No. 3.

HISTORICAL INTRODUCTION

When, in 1641, Thomas Bartholinus republished the lectures and views of his father, he gave us not merely a thoughtful and stimulating treatise on Anatomy fresh, as it were, from the lips of a real investigator but added thereto a synopsis of the current and earlier thoughts upon the subject. For the opportunity to consult first-hand the Fathers in whose writings so much of value is to be found but so largely forgotten through difficulty of approach, this laboratory is indebted to gentlemen like Dr. Weber and Dr. Chamberlin who have presented to the Hamann Museum these rare and valuable sources of information. To return to Bartholinus we find the following stated as the "uses" of sutures (1).

1. To permit free transpiration of the vapors in the brain.
2. For the attachment and suspension of the dura lest it should press upon the soft brain.
3. For the transmission of fibers of the dura through to the pericranium.
4. For the transmission in both directions of vessels carrying nourishment and life to the parts.
5. To diminish the likelihood of fracture of one bone involving also others.
6. To permit more easily the penetration of applications from the exterior.

The hand of tradition is clearly seen in current views upon the sutures when one ponders the six "uses" just enumerated. It is true that number six and to a less extent number five have faded from the modern imagination but numbers two, three and four remain little altered. Number one has undergone considerable change but this change is more in conception of the details than in fundamental principle. We still see the publication of monographs as their theme the relation of early racial closure of sutures to the degree of "intellectuality" and the connection between suture closure and shape of the cranium, both of which ideas can be traced back to the works of Hippocrates. Delightful as it would be to follow out in some detail the development of our present beliefs concerning the sutures, to trace the constancy of these conceptions through the Renaissance to the Anatomists of Antiquity and thereby to realize more fully than we are apt to do the overwhelming influence of tradition, this is really no part of what I have set out to accomplish. I propose to present the facts concerning suture closure and its relation to the racial form and individual contour of the braincase. Those who desire to study this historical aspect of the problem cannot do better than consult, by way of introduction, the scholarly work of Pommerol (15) published in 1869.

In brief, although ancient authors like Hippocrates, Aristotle and Galen were acquainted with the fact that some human crania show multiplicity of sutures whereas others are almost or even totally devoid of sutures, dog-like as Aristotle has it, the fact that union occurs during life does not appear in literature until Fallopius attacked the traditional doctrine in the middle of the sixteenth century. It seems probable however that Fallopius was stimulated to make his observations by his great master Vesalius. At any rate there was rebellion in the air against the classical view that sutures have a close relation with skull form for Sylvius who had once been the teacher of Vesalius, Columbus who like Fallopius had been pupil of Vesalius, and Eustachius all shared the view expressed by Fallopius. Very slowly was this new conception assimilated by the majority of Anatomists and a hundred years later the Bartholins agreed that the relation described by the ancients can be found in but rare instances (1 p. 452.).

According to Bartholin the number and site of the sutures, contrary to the assertion of Aristotle, are the same in both sexes, and unchanged, except rarely, by the form of the cranium. To this Diemerbroek, as quoted by Pommerol, added that deformations take place perhaps during foetal life, perhaps at birth. So far back then must we go for the idea of congenital deformity. Gradually after this time the old Hippocratic views upon cranial form faded into obscurity. But curiously enough they were revived by Lucae and Virchow together with the Hippocratic idea of the relation between suture condition and cranial form, although naturally these latter regarded cranial form as influenced by suture closure which is abnormal in point of time. To use the term of Vesalius, the various "figurae depravatae" described by Bartholin return in the classification of these two writers of the nineteenth century. So striking is the similarity between the views of Hippocrates and those of Virchow, allowing for the lapse of time, that Pommerol gives himself up to the picturesque metaphor of the Father of Medicine and the Father of Cellular Pathology meeting each other across the centuries on the subject of synostosis.

Since the middle of the nineteenth century our ideas of the relation between suture closure and growth of the brain have undergone an inversion so that it is now generally recognized that growth of the brain is a cause rather than an effect of the precise date of suture closure. It is not necessary to press the distinction which will of course be understood throughout the further presentation of this theme. Although fully recognizing this change of view the immediate purpose is a study of the sutures themselves and their union. Just as it is no new thought that some relation exists between shape of cranium and union of sutures on the one hand and development of the brain on the other, so also an impression of racial distinction in suture closure is of considerable antiquity. Pommerol points out that Celsus, in his compendium of medical learning in the first century A. D., refers to the teaching, which be it noted antedates Galen, that crania devoid of sutures occur more readily in warm climates (15). This statement was later clarified by Arranius when he asserted the condition to be peculiar to Ethiopians. Here then we have the germ of a belief that suture closure takes place at a relatively early age in Negroes and other "lower" races. No real advance save that associated with Fallopius has been made since these early times. Winslow and others in the eighteenth century emphasized the analogy between sutural membranes and the diaphyso-epiphysial plane, and soon afterwards Soemmering and Meckel pointed out relationship between state of the sutures and development of the brain.

As regards age of suture union it is useless to dissect closely the unprofitable discussions of the last century, based as they were upon altogether inadequate material of which very few skulls were of well attested age. Fallopius had observed that union occurs and Eustachius had noted that it takes place first in the sagittal suture. In the middle of the nineteenth century union had been observed to occur earlier within the cranium than upon the exterior, and in 1856 Gratiolet enunciated his well known laws regarding the earlier union in Negroes and the precise sequence of closure to which we must revert later on (8). During the famous discussion upon volume and form of the brain in 1861 Broca was unable to draw upon any precise data regarding age of closure but observed that many sutures are still patent in men of fifty and even beyond (5 p. 179). Gradually opinion crystallized into a belief that union begins between forty and forty-five years at least in White Stock (e. g. 17), and upon the evidence of a single male skull of forty-six years Pommerol agreed that closure must commence about forty (15). Topinard had Pommerol's work to fall back upon but in addition had observed as closely as possible other material and is more definite. He notes that the period of union for each suture varies considerably but hazards the opinion that if the sutures are yet patent the individual is thirty-five or less, that commencing closure in the sagittal indicates about forty years, in the coronal fifty years, and that if the temporal be united it indicates an age of sixty-six or more (23). Ribbe in 1885 had fifty skulls of supposedly known age of which forty were those of White Stock. The earliest occurrence of union among these was at twenty-one years and the latest at fifty-five. Taking the mean he concurred that forty to forty-five is the probable average age of commencing closure (16). As regards age identification by suture union Ribbe did not believe it possible to estimate closer than fifteen to twenty years. Dwight set the age of a cranium showing no suture closure at less than thirty years (6). Dwight's material consisted solely of paupers whose ages were apparently not verified. One cannot tell whether, in many of his cases, the statements regarding closure refer to exterior or interior or both. He regarded the date and order of closure as very irregular and not of much value as an age indicator. However he recognized that the same points are not first involved on both sides and that the inner lambda is often patent after all other areas are united.

All the foregoing observations must be regarded as based almost entirely upon external union which may proceed very differently from internal closure. Parsons and Box in 1905 however began to emphasize the significance of internal union (13) and upon this basis they agreed with Dwight.

Frédéric, in 1906, working under the inspiration of Schwalbe who had himself studied this problem in connection with his investigation of the Neandertal skull, made a very comprehensive examination of suture closure in the collection at Strassburg. Frédéric had at his disposal 255 European crania and 119 non-European skulls all of known age. Of these however only 91 European and 13 non-European crania of both sexes were opened so that the internal surface could be satisfactorily examined (7 Table VII.). Frédéric therefore based his conclusions mainly upon the external condition of the sutures of the vault in the unopened cranium. Into the details of Frédéric's observations it is unnecessary to enter here. He decided that it is not possible to determine the age of any skull by the condition of suture union closer than within one decade and hence gives a table (his Table VIII) showing in percentage form the complete closure of each suture externally and the sutures of the vault internally for each decade. This is not very helpful nor is it encouraging. Hence the whole question of the relation of suture union to age remains an intricate and unsolved problem, hopeless alike in the scattered confusion of the data, in the inadequacy of the material utilized and in the unreliability of the information upon which determination of age has been made.

The articles by Pommerol, Ribbe and Frédéric are the main contributions to this subject so far. Each is excellent in its way but all fail to add much to our real information upon age relations, the two former from lack of material and the last mentioned from method of treatment. Parsons and Box, on the other hand, although they had access to but 82 skulls of known age, inspire the greatest hope. They make the very important observation that no estimate of age should be based upon the condition of ectocranial sutures when the inside of the skull can be examined, thereby indicating their opinion that a more definite relation to age might be obtained from a study of endocranial sutures were such a collection of sufficient magnitude available for review. It is at this point that we take up the work.

MATERIAL AND METHOD OF EXAMINATION

From a historical survey of the problem before us it is plain that little real progress has been made and that a proper investigation of the question postulates three necessary conditions. The material must be ample enough to justify it as a sample of the population studied: if both sexes and more than one race or Stock can be examined so much the better. In addition to sex and race age must be known: hear-say will not suffice; there must be some adequate method checking up the given age so that confidence in its accuracy may be inspired. The crania must be cut so that easy inspection of the entire interior is rendered possible. During the past ten years we have endeavored to fulfil these conditions and although accumulation of a satisfactory sample is tedious and difficult I feel that the material which we shall present is adequate for the determination of at least the general features of suture closure.

Drawing upon the crania of more than 1,000 individuals we have rejected all those of which the age record was imperfect or was later discovered to be fictitious, and all those of which the skeleton was not available for comparative study. The series left to us comprises the crania of 307 male Whites, 58 female Whites, 120 male Negroes and 29 female Negroes, a total of 514 skulls all of known age.* It is not suggested that the female crania in the series are of any independent value but even so small a group is useful as a check upon the age relationship shown by the corresponding males. We shall base our conclusions upon the male White series and shall compare with this standard the con-

*Note—These numbers refer to the collection in 1921 when this survey was commenced. The numbers are greatly increased now (March 1924.)

ditions found in the females and Negroes. So far as actual numbers go this collection far outstrips any material hitherto available.

It is unnecessary to dilate upon the precise method of checking up the age record of the individual for this has been discussed in a previous paper (19 pp. 289–292) but since that date we have learned to have much greater confidence in the internal evidence of the skeleton itself upon the age problem. As yet little has been published of the great accumulation of data dealing with skeletal age and its significance in Anthropological work. Graves has set forth a preliminary note dealing with the scapula (9) and Stevenson has presented the evidence for epiphysial union (18). These together with my own researches on the pubic bone form merely a beginning for reference. The harmony which is evident among these studies is also to be found in many other investigations not yet ready for the press. Hence it must not be assumed that these alone form the basis of our conclusions. No effort has been spared to obtain complete satisfaction in the question of age which is so fundamental for all our researches. In brief then we may state that from the point of view of age determination the W. R. U. collection is dependable so far as is humanly possible and much more dependable than the vital statistics upon which actuarial investigations for insurance companies are based.

Like our predecessors we have adopted Broca's arrangement of complication of sutures, degrees of closure and subdivision of particular sutures except that we have followed Frédéric in his inversion of Broca's enumeration of the amount of union. Thus, in our records, 0 indicates no union and 4 complete closure: 1, 2, 3, refer to the amount of union, one-quarter, one-half or three-quarters as the case may be. These schemes are set forth in Frédéric's paper (7 pp. 376, 377, 385). We do not differentiate between union which has progressed half-way along a suture and closure which involves a total of half the length of a suture but is exhibited in separate discrete areas. The scheme of Oppenheim dividing sutures into pattern forms and degrees of excursion we have set aside as too involved for practical use (12). The now accepted subdivision of the sutures of the vault is seen at a glance from Oppenheim's figure or Martin's figure 243 (11 p. 627).

To facilitate the accumulation of data we devised a form which can be filed on the card catalogue system and records the type of each subdivision of every cranial suture and the degree of its closure. Separate sheets are used for external and for internal sutures. At the head of each sheet the following general data are recorded: Number of skull, race, sex, age, greatest length, greatest breadth, cephalic index, cranial capacity, sites of Wormian bones. Thus we had at hand all the information which we felt might be of service in discussing suture closure. The junior author wrote down upon this form the data obtained from our laboratory records and filled in the condition of the sutures and their union. The completed record was then gone over anew by both authors together and the data checked. Consequently the type of suture and the degree of closure are to be understood as the joint observation of two individuals. Where there was any doubt concerning the amount of union the suture was examined under a Zeiss binocular dissecting microscope at ten diameters. It will be realized that the observations are correct only for the external and internal surface of the cranium and we have no accurate information regarding the condition of the suture deep in the substance of the skull wall. The relation between union without and within and between surface and substace must receive special attention, but we believe the condition recorded to be accurate for the surfaces and have spared no pains to this end.

In order to make possible a study of the large and unwieldy mass of data we first reduced to the comparative simplicity of a formula the conditions found in each particular cranium. The following is a typical example showing internal closure of the vault sutures:—

Internal union. Skull 649, male, White, age 22.

$$\text{Sagittal } 1141;\ \text{Coronal } \begin{array}{l}\text{R. } 230\\ \text{L. } 110\end{array};\ \text{Lambdoid } \begin{array}{l}\text{R. } 020\\ \text{L. } 010\end{array}$$

This formula should be read thus:—Union of

Sagittal suture—	pars bregmatica	one quarter	pars obelica	complete
	pars verticis	one quarter	pars lambdica	one quarter
Coronal suture—	Right side		Left side	
	pars bregmatica	one half	pars bregmatica	one quarter
	pars complicata	three quarters	pars complicata	one quarter
	pars pterica	none	pars pterica	none

Lambdoid suture—Read for right and left in precisely the same manner as the coronal has been presented.

In the ensuing pages it will be of advantage to refer to special cases for which this formula permits simple presentation.

THE PRELIMINARY SURVEY

Having assembled the evidence in the manner just indicated we took the male White series numbering 307 specimens and plotted out on millimeter paper the degree of union for each cranium, arranging the series in order of age. This was a very lengthy and tedious piece of work for it involved making a separate graph for each separate part of every suture for the inner and for the outer face of the skull and also for each side of the head. We then averaged the closure for each total suture and plotted right and left side graphs anew. In return for the considerable time spent upon this procedure we expected to be repaid by the convenience thus attained in examination of our data. Nor were we disappointed for, in spite of the individual difference which must be expected, we could see clearly at a glance that there is a definite trend in the progress of closure in relation to age. From these first graphic results we were able to observe roughly the commencement, progress and completion of union in every segment of each suture. It was also apparent that there are marked exceptions in certain skulls to the usual course of union and, passing rapidly from chart to chart we were enabled to note that as a rule anomaly in closure of one suture is associated with anomaly in closure of all. This segregation of anomalous skulls gave us the chance to eliminate them from the final graphs and so define more readily the age relationship of suture closure in the male sex of White Stock. Hence we were able to make a rough preliminary draft of what may be termed the modal type of suture union. The graphs also permitted us to observe that the anomalous instances fall clearly into two classes, quite orderly in their progress, of acceleration and of retardation in suture closure.

The preliminary survey of the male White Stock being completed we undertook a similar presentation of the male Negroes and of the females of each Stock. This led at once to elimination of the instances of abmodal progress in each of these series and gave us a basis for comparison of closure progress in each sex and Stock with our male Whites which we used thereafter as a standard.

Barring exceptions which must receive attention in their turn, it was now clear that there is an orderly age sequence in the progress of suture closure and that sex, Stock, cephalic index and cranial capacity affect this age sequence only in minor degree or not at all. We were forced to the conclusion that far too much has been made of the influence of each of these factors. We could also see that the time linkage is more obvious in the progress of endocranial union than upon the outside of the cranium, thus fully bearing out the helpful suggestion made by Parsons and Box. At this juncture we shall not attempt a discussion of the relative value of closure progress within and without the cranium but content ourselves with the statement that, as a result of our preliminary study, we have adopted the closure progress of the endocranial sutures of the male White series as our standard for future work. Our initial problems were then, first, the adequate presentation of the modal type of closure progress in relation to age among the male Whites and secondly, the discussion of abmodal progress in this series.

USE OF THE MOVING AVERAGE OR TREND

Realizing the minor difficulties in problems involving age by the arbitrary subdivision of human age into units of one year we resolved to adopt the moving average covering three year intervals as our method of presentation. A few words upon this subject are therefore pertinent. All our graphs, both preliminary and final, are historigrams. That is to say they are numerical records of the degree of suture union (the variable) during successive periods of time, the unit of time being naturally one year. The degrees of union are plotted as ordinates and the age periods as abscissae. Even after the elimination of plainly abmodal instances the graphs were too large and unwieldly for publication for each graph showed precisely the state of closure for every skull in the entire series. The individual differences, though not large, were sufficient to obscure in a measure the general trend of progress. It was necessary therefore to smooth the graphs somewhat. If the total number of observations is relatively small, as must necessarily be the case in an investigation such as this, there may be grave danger of errors creeping in through too vigorous smoothing. We desired in consequence to smooth just as conservatively as we could and therefore we chose to adopt as our basis the moving average over a three year period.

If an individual give his age as say twenty-five years and we have no record of the actual date of birth we must remember that his precise age may be anywhere from twenty-four years and six months to twenty-six years all but one day, according to the individual's own method of computation. Each year of life therefore includes at the maximum eighteen months and successive "years" overlap. Further, as a result of experience, we find that mistakes of one year in either direction are not uncommon in the statements of people in ill-health or under the slightly embarrassing circumstances of being asked personal questions by nurse or doctor. I believe that with difficulties of language the individual error may in certain cases be rather more than one year although there is no means by which this can be corrected. If then we sum up the states of union for all individuals during three successive years of life as given in the records and take the average of these we shall not be far from the actual mean value for the state of union characteristic of the second of the three years. The plotting of these three year averages will not give an entirely smooth curve for the number of instances naturally varies from year to year in a comparatively small series. We have seen no reliable method by which we could eliminate from our curves the fluctuations resulting from this fact. As I have already intimated the excessive smoothing of graphs built up from a small series is fraught with danger. Our final curves therefore are not smooth but I maintain that the advantages of retaining the irregularities outweigh the possible disadvantages in the present study. In spite of defective smoothing I shall refer to the curves as illustrating the trend of union which in point of fact they actually do.

By the nature of the method the moving average tends to indicate commencement of closure one year earlier than is actually the case and completion of union one year after the date at which all specimens show entire fusion of the suture. It is doubtful however if this is a real error for, as has been demonstrated, the precise beginning of any "year" of life is uncertain and the individual variation seems to extend over a year or two. It is true that during the progress of the work we were considerably impressed by the relatively slight variation from individual to individual and were very suspicious of this observation since it is so strangely at variance with accepted ideas. But Stevenson's work on union of epiphyses confirms us in the belief that in suture closure as in epiphysial union the current expectation of great individual variation is unnecessarily exaggerated. As will be demonstrated in the body of this work a larger acquaintance with the facts regarding suture union forces one to the conclusion that apparent individual deviations from the modal type of closure can usually be explained by accelerated or delayed union which are either phylogenetic or pathological in nature, or by inaccuracy in the age record. I am perfectly aware of the pitfalls of circular reasoning and it will be one of the most important tasks of this work to convince the reader that we have not fallen into one of these pitfalls. At the moment all we can do is to ask indulgence until the full evidence is presented. Although we have come to believe that suture closure, like epiphysial union, once it has commenced, is not normally a long drawn out affair, we are convinced, in view of the facts already presented, that it is safer to use the evidence of the moving average over three "years" regarding the commencement and completion of union than to insert the actual dates given by our present material. Except the sagittal all sutures are bilateral. The moving average for *both* sides is therefore the basis of our final statements regarding progress of union.

GROUPING OF CRANIAL SUTURES

In discussing the cranial sutures it is convenient to have some grouping by which several related sutures can be included in a single expression. At present the recognized groupings are ill-defined and there is considerable variation according to the particular author in the exact sutures comprised in each group. The older Anatomists grouped the sagittal (and metopic), coronal and lambdoid sutures together as the sutures of the vault and this classification is convenient for our present purpose. Of late however some authors have included the squamosal suture in this group (e. g. Bolk 2). I believe this addition to be unfortunate and that it should not be continued. The older usage will be followed in our presentation. The grouping of the three sutures of the vault (four with the metopic) is merely one of convenience and it will shortly become evident that these sutures are very widely divergent in the significance of their closure progress. As this difference in significance will be shown to be of a phylogenetic nature no further allusion need be made to it at this juncture. It is convenient classification authorized by usage but of no morphological value. Although the metopic may remain open until late in life its appearance is one of the indications of abmodality in suture union and therefore will not be considered by us in our earlier discussions.

There are certain sutures which can readily be classified together into a group which we have found to be closely related to each other in our studies of the phylogeny and growth of the cranium. These comprise in order the spheno-temporal, squamous, parieto-mastoid and occipito-mastoid sutures, a group for which Lyon has suggested the descriptive title of circum-meatal sutures. This term will be consistently used throughout our work for it shortly and aptly denotes their relation in phylogeny and growth.

The spheno-frontal and spheno-parietal sutures form a small group related from comparative and developmental points of view to both the circum-meatal sutures and to the lower coronal. It will therefore be styled the accessory group.

The spheno-occipital or basal suture has its own significance and forms a group by itself. Like the metopic it does not enter into the present study since it is already closed before the beginning of adult life. We propose then three groups of sutures with which we must deal, namely the sutures of the vault, the circum-meatal sutures and the accessory sutures.

In this work we shall take up for consideration the modal and abmodal progress of endocranial suture union as exemplified in the male White series. In later communications we shall discuss endocranial union in its relation to sex and Stock and finally follow out its evolution in phylogeny.

LAPSED UNION

Before beginning a detailed presentation of the results of our study of suture closure it is necessary to discuss a condition by no means uncommon in the sagittal and lambdoid sutures but rarely found elsewhere upon the endocranial aspect. This condition I shall term lapsed union. It is characterized by apparent failure of union over a greater or smaller part of the suture accompanied by a heaping up of bone tissue along the edges of the unclosed part. While bone along a suture margin is still in a state of activity it presents a well defined granularity of texture very difficult to describe but none the less easily recognizable. After activity has ceased the granularity gives place to a smoothness of texture which can be likened roughly to a waxy surface. The heaped up bony margins of a suture in the condition to which I refer show this characteristic evidence of quiescence which absolutely differentiates them from the margins of a suture still in a state of active closure. The condition is not limited to Man; all mammals show the same features. There is no doubt that such sutures have been classed as patent by previous investigators and owing to this misinterpretation of the state of the suture unnecessary confusion has been injected into the age relationship of suture closure. Just why the condition develops in the sagittal and lambdoid sutures of all mammals is not yet apparent but it must nevertheless be reckoned with and discounted. A suture in this condition is unlikely to close to any greater extent. In our observations we have marked the condition by an asterisk and when we came to assemble our results we found lapsed union accounted for many of the apparent anomalies in closure of the lambdoid suture and for the greater proportion of anomalies in the sagittal. Such sutures have therefore been classed as united.

This condition of lapsed union is by no means confined to the cranial sutures. It occurs not infrequently at the junction line between epiphysis and shaft in the long bones particularly at the upper end of the tibia and the head of the femur. But by far the most frequent appearance is at the line of union between the eiphysis for the iliac crest and the body of the ilium. Dr. Stevenson's work upon epiphysial union demonstrates that fusion of this epiphysis is really of considerable value as a time marker once one learns to discount the appearance of lapsed union. In his description of skeletons for the Nubian Survey Wood Jones refers to the "long delay" which the union of this epiphysis with the ilium presents especially at the hinder end (24 p. 256). Undoubtedly such cases should be classed as lapsed union.

In dealing with differentiation in the pubic bone I have shown that a condition akin to lapsed union is not uncommon in the building up of the ventral margin and upper extremity especially in White Stock (19 p. 308). It results from failure of complete ossification in the epiphysial mass on the pubis. I have also shown that the condition is present in other mammals (20 p. 414).

The peculiar features of lapsed union or lapsed ossification are always the same and are readily appreciable once their significance is understood. It would seem as though Nature grew tired sometimes of carrying on her morphological work to its completion and left the structure imperfect in appearance though not in function. The discounting of lapsed union is an important part of the interpretation of both epiphysial and suture closure.

Part I.—Male adults of White Stock

THE DETERMINATION OF MODAL PROGRESS

The 307 skulls comprised in the male White series of known age are those finally chosen as suitable for the present work since there is no reason to dispute the record of their ages and the entire skeleton is available for study. But since these skulls are spread over the life period from eighteen to eighty-four years inclusive, relatively few belong to each year and in the later part of life there are gaps of a few years without skulls. Despite this inevitable drawback the series is representative and consideration of its members inspires confidence that no essential part of the story of suture closure is defective. The collection is constantly growing and now is considerably larger than it was when the final choice of the series was made more than three years ago. Although we have been unable to include the additions in the standard series our confidence in the essential accuracy of this series is in no way impaired.

At first sight the number of skulls belonging to any particular decade may seem perilously small upon which to build a statement of suture union so dogmatic as we are about to present but it must be remembered that the skulls belonging to the period during which union actually occurs are not to be considered as alone in presenting the evidence. They determine only the progress of union once it has begun. The uniform absence of closure in the particular suture in question in all skulls below the age of beginning union and the equally uniform occurrence of complete closure, barring occasional lapsed union, in all skulls beyond the age when completion of closure takes place, are the evidence which delimits the period of actual union and gives point to and confidence in the statements relative thereto.

In attempting to ascertain the modal progress of closure it is obvious that we should meet with exceptions to the rule. Already in our preliminary graphs in which all 307 skulls were represented the general trend of progress was sufficiently clear to us with our knowledge of the skeletons included in the series. But it was equally apparent that some skulls showed more, some less deviation from the rule. Variability in Man and particularly in the skull, prepared us for this. But the proper elimination of the variant skulls presented a very difficult problem. We had to devise some test which should not be directly related to suture closure itself, a test which should determine upon general skeletal grounds whether or not a skull ought to be retained in the first formulation of modal progress. A problem of somewhat similar character was presented in the survey of pubic symphyses which ultimately resolved themselves into three types, better marked it is true in the Negroes but nevertheless quite apparent also in the Whites. The essential feature of the pubic subdivision is the fact that certain human symphyses show their anthropoid origin more clearly than others. I have therefore spoken of the anthropoid strain of symphysis and of the regressive form (21). The latter type is more numerous than the former and therefore more characteristically human. It appeared possible that in this subdivision we had a means of separating skeletons into groups without reference to the skull and still with some reasonable hope of finding a resultant effect upon the graphs of suture union.

Between the anthropoid and regressive symphysial types there occur certain symphyses, relatively much less numerous than either of the other groups. The exact position of these it is difficult to determine. Many are certainly retrogressive examples of the anthropoid strain, nevertheless this form is properly intermediate between the other two. Now it is characteristic of the anthropoid strain that the pubic age relationships fall nearer to those of the Giant Anthropoids and there is also a clear difference in age-relationship of the skeleton between human beings according as they exhibit the anthropoid strain or the regressive form of symphysis. The great mass of evidence for this assertion must await its turn for publication; at the moment we will have to accept it as a postulate. Upon this basis we first of all cut out from our series all the skulls belonging to skeletons of the anthropoid strain. Immediately the graphs of suture closure reacted in a very remarkable way for most of the skulls eliminated exhibited an unusually advanced state of closure for their age. Naturally this sweeping reduction seemed to take out some specimens which we would rather have retained but we feared to meddle with the working of the plan on which we had decided.

In my investigations upon the symphysis I demonstrated that there are some skeletons which show an accelerated type of differentiation (metamorphosis) and others in which differentiation is undoubtedly retarded. At the very beginning of the skeletal work these gave considerable worry and caused me to doubt gravely the accuracy of our age records. After a close investigation I was convinced of the essential accuracy of these records and collateral evidence assured me that there is a variable age relationship in the skeleton just as there is in other tissues and in the external features of the individual. As I have pointed out this acceleration or retardation has no relation to the type of symphysis (21). Either condition may and does occur in anthropoid strain or regressive form. Hence our next step was to eliminate all skulls belonging to skeletons which exhibit a marked anomaly of skeletal age-relationship.

For several reasons this further step was necessary. In the first place elimination based upon an anthropoid strain in the pubic symphysis affects only skeletons of the third decade. As a matter of fact it was among the skeletons of this decade that we were most in need of guidance. But for later decades we had no method of elimination upon which we felt that we could rely except the general one of skeletal age-relationship. In a very valuable and unique piece of work Bolk has shown that there are skulls which exhibit partial or complete closure of certain sutures, notably the sagittal and masto-occipital, at an early age (3, 4). In these skulls the union probably occurs entirely or for the most part before the age of seven years. We must expect to find such skulls among our series also and it is probable that, had Bolk been able to examine the entire skeletons of the children, he would have found other evidence of an unusual precocity in bony differentiation. At any rate, upon these grounds, we felt safe in making a further elimination upon the following basis.

Bolk's remarkable findings in children's skulls lead one to suspect that there may also be a type of skull in which the closure of sutures is very long delayed or never takes place. As a result of our investigations we believe that the latter condition does occur. We therefore eliminated all skulls which we felt perfectly certain belonged to Bolk's precocious group and also those of this antithetic class.

As the result of these drastic reductions our material grew very small but at the same time remarkably uniform and harmonious in the information it now gave regarding suture closure. From this greatly restricted material we were able to discern clearly the real direction and relations of the curve of closure. The method employed is the same in principle as the one which I used to make my original estimates of age-relationship in symphysial differentiation (metamorphosis) but in that work determination was a much more prolonged and oftentimes a very discouraging process for, incidentally, so much of the basis of our skeletal work had to be laid before reliable results could be obtained for any portion of the skeleton. This basis is now built up in large measure though by no means complete but it seems probable that features of differentiation slowly and with difficulty gathered in the earlier researches will be of the greatest advantage in guiding and safeguarding the interpretation of other parts of the skeleton successively studied.

Having then obtained upon a very restricted but methodically selected material the essential data for closure of the sutures we next set about reclaiming in a guarded manner some of those specimens which we had lost. When however we finally reject a skull it must not be imagined that our guide has been simply the state of closure of the particular suture in question or yet of the sutures in general; the reason has always been a very definite one, based upon evidence in the skull or elsewhere in the skeleton of some anomaly which would give us pause, at this period of the investigation, in laying weight upon its evidence, however favorable this evidence might be to the special problem under consideration.

In reading of the method of elimination and selection of our crania it may well be wondered why we have paid no attention to the view of Ribbe that there is a significant difference in order of closure of sutures in dolicho- and brachycephalic skulls. The point will be discussed more fully later. Suffice it for the moment to state that we have found no evidence whatever of any truth in the assertion. It must also be remembered that Gratiolet made a distinction in order of closure between higher and lower races of mankind. What constitutes a higher and what a lower race may be open to considerable question. But it is generally agreed that the negroid races belong to the lower group and certainly it is what Gratiolet had in mind when he penned this sentiment (8). Evidence upon the subject will appear from comparison of our results on Negroes with those on Whites. Certainly there can be no differentiation between higher and lower races so far as Whites alone are concerned. We shall later have something to say upon the validity of the argument touching White idiots.

THE SAGITTAL SUTURE.

(Figs. 1 & 2)

The averages for the several parts of the sagittal suture have been gathered together into one graph from which the mean progress of the entire suture may easily be read. It is shown along with similar curves for the coronal and lambdoid sutures in Fig. 1. One should read this graph and that showing union in constituent parts of the suture (Fig. 2) at the same time. To avoid a disjointed statement we shall discuss them together. Union begins at twenty-two years or slightly earlier in the obelic part, spreading by the end of the twenty-third year to all other parts of the suture. In the obelica closure progresses rapidly to its completion at twenty-nine. In the other parts union does not gather speed until the end of the twenty-sixth year when it takes a spurt forward and has already reached the stage of closure represented by 3.5 at twenty-nine years. By thirty-one closure is almost complete in these three parts but the terminal stage is delayed until thirty-five.

The obelica then runs a course by itself and the other three parts of the suture form a harmonious group with a rather different age relationship in closure progress.

Fig. 1. naturally gives the average of all four parts and since there is marked distinction between the curve of the obelica and those of the other parts the composite curve reflects in certain degree the characters of both types. The very gradual rise of the curve just before twenty-two years is the effect of the early obelic commencement. Thereafter the composite curve follows fairly closely the curves of the three other parts which easily overpower the obelica in the final average. The composite curve is more difficult to interpret than those of the constituent parts which we might call the analytic curves: it gives only a general indication of the precise trend. But its particular value lies in the fact

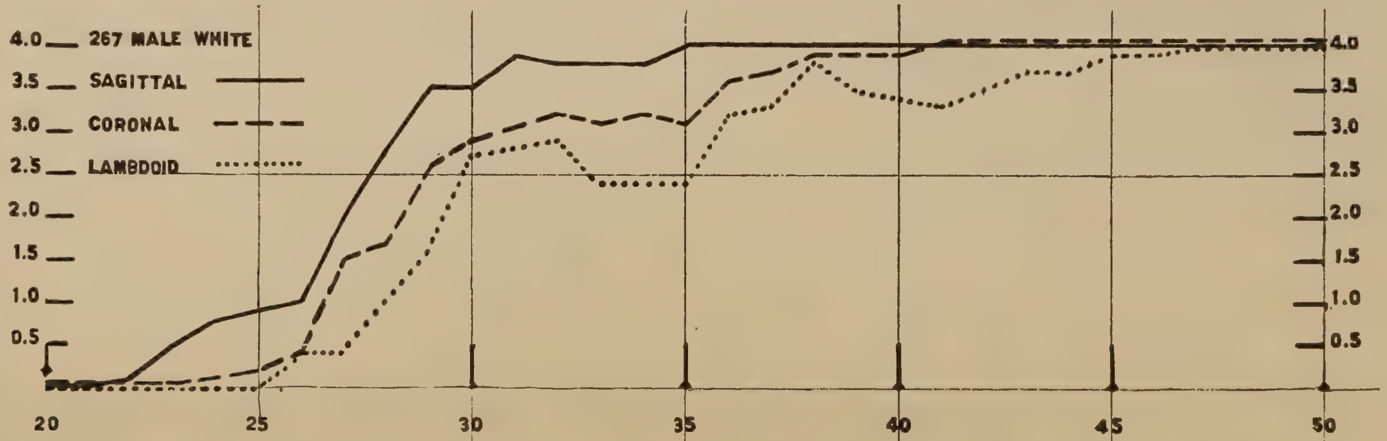

FIG. 1. Endocranial closure progress in the sutures of the vault. The relative order is shown. There is great activity between twenty-six and thirty years but lethargy before and after this period.

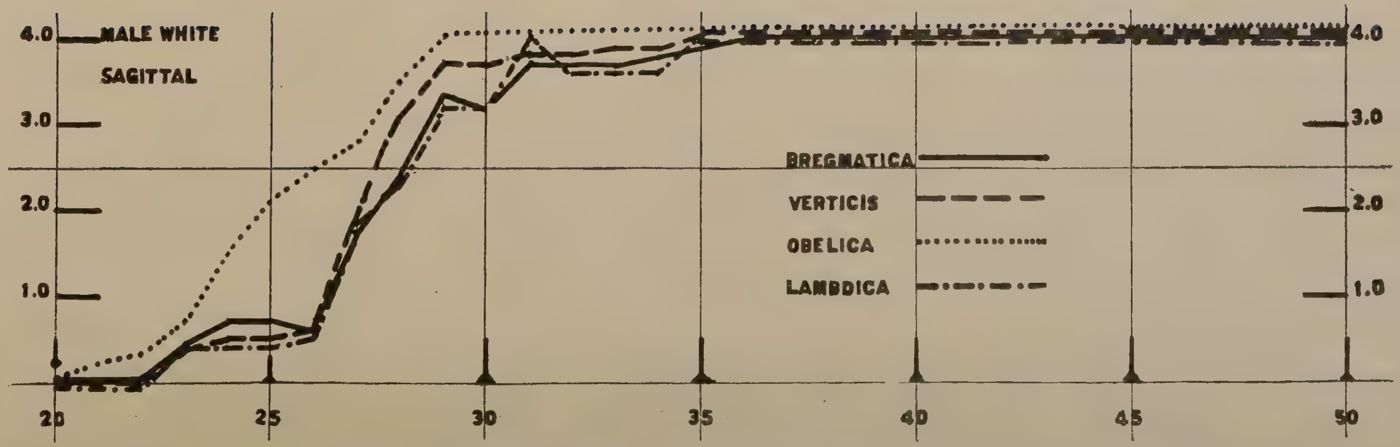

FIG. 2. Endocranial closure progress in the sagittal suture. The pars obelica has a progress of its own rather different from that exhibited in the other segments.

that it is so sensitive to initial and terminal changes. It must commence to rise as soon as any part of the suture has really begun to unite and it cannot reach completion until the last part of the suture is actually closing.

The difference between the curve of closure of the obelica and those of the remaining parts (the B. V. L. curves) is quite obvious but its significance is not entirely clear. Neither the curve of the pars verticis nor that of the lambdica at all approaches it in form. Of course one may assert that it is a primitive part of the cranium associated with the parietal foramina, but this is no satisfactory explanation. The relation of the foramina to the obelica varies greatly in different individuals. We must admit that so far no adequate reason for this peculiarity has presented itself.

The similarity in the curves for the partes bregmatica, verticis and lambdica is just as striking in its way. The pars verticis and the pars lambdica are separated by the obelica and yet the courses of union in the two run closely parallel. The initial lethargy and the terminal delay observable in all are not particularly features of the sagittal suture: they are rather a skeletal characteristic for the years during which they are exhibited. As such they will be observed again and again and must receive attention later.

The main features of closure progress in the sagittal suture can be briefly set forth in the following manner.

Male White endocranial closure commences at twenty-two years with (a) a gradual rise to 1.0 at twenty-six, (b) a sharper rise to 3.9 at thirty-one, (c) a terminal oscillatory delay with (d) complete union at thirty-five years.

No skulls of thirty-five or over, excepting instances of lapsed union, fail to show complete closure. The critical period between twenty-two and thirty-four years is represented in the collection by forty-two skulls. The tabulation of the entire series with reference to closure of the sagittal suture is the following:

Age	Period	Number of skulls	
		Retained	Rejected
18–21	pre-(a)	4	0
22–25	(a)	11	2
26–30	(b)	16	6
31–34	(c)	15	1
35–84	(d)	221	31

Total retained in series	267
Total rejected	40
Grand total	307
Percentage of discards to grand total	13.3
Percentage of discards (a)–(c) inclusive on total of this period	17.6

The value of this table lies in the ease with which one can judge from it the reliance to be given to the conclusions drawn from the survey. The total retained in the series, the total rejected, the grand total and the percentage of discards to the grand total remain the same throughout the survey of all sutures except the lambdoid. Why we have found it necessary to make changes in the survey of the lambdoid will become clear in discussion of that suture after presentation of ectocranial closure progress.

It is in the pars verticis that one finds lapsed union to occur most frequently. Here actual complete closure may be long delayed and indeed it is even possible that it is never completed in some individuals. These instances of lapsed union must not be permitted to confuse the real issue. They are comparable to the cases in which symphysial outline remains incomplete throughout life. They are readily recognized by the heaped up character of the bone along the margins of the suture. The examination of a score of skulls thirty-five years old and over will give far more confidence than pages of description in reading correctly this feature. The same condition is found especially in the lambdoid part of the lambdoid suture and occurs in other mammalian crania.

In examining critically the table of numbers of skulls used the first objection is the small number in the series before union begins in the sagittal suture. Bolk's series of 1820 juvenile skulls ends just at the age when our series commences and of this great number only 71 showed partial or complete obliteration of the sagittal suture. It is therefore clear that we have been able to plot the modal commencement correctly. The second apparent defect is the small absolute number of skulls upon which we base our determination of actual closure progress. That we have really obtained a correct record of the length of time over which the progress is spread before union is completed is evident from the fact already stated that none of the 221 skulls of over thirty-four years, barring always the instances of lapsed union, exhibits imperfect closure. These two limits of the progress of union being ascertained it cannot well be objected that our curves do not give a reasonably correct idea of the course of union during the time when it is in progress for whereas we have retained forty-two skulls we have rejected only nine. Nevertheless it is important to give the reasons for rejection of these discards. The condition of the endocranial sutures of the vault in these nine skulls can be obtained at a glance from the following table of their closure formulae. The reader will find directions for reading these formulae on page 332. They should be considered alongside the graphs of modal closure progress in the three sutures (Figs. 2, 3, 4).

Age 22.	No. 649.	Sagittal 1141;	Coronal	R. 230 L. 110	; Lambdoid	R. 020 L. 010 .
Age 24.	No. 667.	Sagittal 3333;	Coronal	R. 444 L. 444	; Lambdoid	R. 344 L. 342 .
Age 26.	No. 653.	Sagittal 0000;	Coronal	R. 000 L. 000	; Lambdoid	R. 000 L. 000 .
	No. 490.	Sagittal 0000;	Coronal	R. 000 L. 000	; Lambdoid	R. 000 L. 000 .
Age 27.	No. 317.	Sagittal 0000;	Coronal	R. 000 L. 000	; Lambdoid	R. 000 L. 000 .
Age 28.	No. 94.	Sagittal 0042;	Coronal	R. 000 L. 000	; Lambdoid	R. 000 L. 000 .
Age 29.	No. 436.	Sagittal 4444;	Coronal	R. 440 L. 441	; Lambdoid	R. 441 L. 441 .
Age 30.	No. 238.	Sagittal 0000;	Coronal	R. 000 L. 000	; Lambdoid	R. 000 L. 000 .
Age 34.	No. 301.	Sagittal 1144;	Coronal	R. 444 L. 144	; Lambdoid	R. 000 L. 000 .

Three of them, Nos. 649, 667 and 436 were originally thrown out as belonging to skeletons in the category of the symphysial anthropoid strain. All show plain anomalies of suture closure and, unlike certain others of the anthropoid strain, have not found their way back into the regular skull series. It is probable that we would not have dared to eliminate No. 649 on the basis of the sagittal suture alone but the condition of its coronal and lambdoid sutures renders uncertainty impossible. The other two are cases of precocious union such as Bolk found. One would not care to hazard at this stage of the investigation just when union did take place but it may be recalled that Bolk found it to occur usually by seven years.

The other six specimens deserve a somewhat fuller consideration.

No. 490 age 26, shows no endocranial closure of the vault sutures. There is obviously therefore some retardation in cranial differentiation. The symphysis is in phase IV but is an example of the intermediate type. Hence the skeleton is one in which anomalies might justly be expected.

No. 317 of age 27 required explanation in the symphysial work (19, p 316). The skeleton is that of a rachitic dwarf who showed extreme kyphosis and many anomalous conditions resulting from retarded development. It is to be expected therefore that the cranium would also show markedly retarded differentiation.

No. 94, age 28, is a case of extremely anomalous symphysis. It shows no closure whatever endocranially of the coronal and lambdoid sutures or of the bregmatic and vertex parts of the sagittal. The obelic part is completely closed and the lambdoid half closed.

Nos. 238, age 30, and 653, age 26 show no endocranial closure of these three sutures. The latter has a symphysis of the anthropoid strain, the former of the regressive type in phase VI. We have in these two specimens a condition where deficiency in cranial suture closure seems at variance with the state of the symphysis.

The same is true of No. 301, age 34, but this cranium is easily seen to be anomalous and no reference is needed to the entirely modal symphysis in phase VI. The bregmatic and vertex parts of the sagittal and the bregmatic part of the left coronal are only one-quarter closed while the other parts of sagittal and of both coronal sutures are fully united. The lambdoid suture is completely patent on both sides.

In summary of the nine discards we note that three show a condition of precocious suture closure harmonious with the state of the symphysis; three exhibit retardation of suture closure associated with retardation or anomaly of the symphysis; and three only present such divergencies in skeletal time relationship that they require further study for their elucidation.

The absolute lack of union in any of the vault sutures characteristic of several of the foregoing rejects is not so striking in the third decade as it becomes later in life. Had it not been for the facts that we have been able to examine the entire skeleton and that we possess records regarding age which we believe above suspicion we dared not have eliminated these. At the moment it is necessary to point out that if sutures are to remain patent throughout life or the greater part of it some of these anomalous skulls may be met with in such an age period as this when identification of the anomalous specimen by the skull alone would be a sheer impossibility. The determination of these skulls as unacceptable must be made upon the rest of the skeleton. This is one of the reasons for retaining in our series of skulls of known age only specimens of which the entire skeleton could be studied.

THE CORONAL SUTURE

(Figs. 1 and 3)

In dealing with the sagittal suture we had a comparatively simple problem for its position in the median sagittal plane postulates for it a relative harmony of influences impossible to assume for a bilaterally symmetrical suture like the coronal or lambdoid which bear so very different a relation to the median plane of the body. Reference to the graph of the entire suture (Fig. 1) shows that in commencement and in completion of union and therefore in the whole course of its closure the coronal suture lags somewhat behind the sagittal. This fact is well known and with this statement previous authors have generally been content. But the analytic graph (Fig. 3) showing the closure of the individual parts of the suture gives a very different conception of the progress of union in the suture. Omitting the pars obelica of the sagittal which is a law to itself, one cannot fail to be impressed with the general similarity of the curves of closure in the three other parts of the sagittal with those of the partes bregmatica and complicata of the coronal. Although these latter commence to unite rather later than the sagittal their curves of closure rapidly catch up and by twenty-nine years the degree of union is the same in both groups. Thereafter the curves run along practically parallel, final completion being somewhat delayed in the coronal. For the pars pterica the progress of union is quite different and it is obvious that it is the radically different course of this part which, when averaged in with the others, brings about the apparently simple lagging in union compared with the sagittal in the graph of the entire coronal suture.

Considering then first the partes bregmatica and complicata together we note that union commences at twenty-four years, quickly gathering speed and reaching the point indicated by 3.4 at twenty-nine. From this age onward closure proceeds more slowly and with oscillations. Complete closure, that is to say, attainment of 4.0 by the curve finally occurs at thirty-eight years.

The facts may be presented thus:—

Male White endocranial closure commences at twenty-four with

(a) a gradual rise to twenty-six, after which

(b) a steeper rise till twenty-nine years, and then

(c) a much slower and more erratic progress towards

(d) complete closure at thirty-eight years.

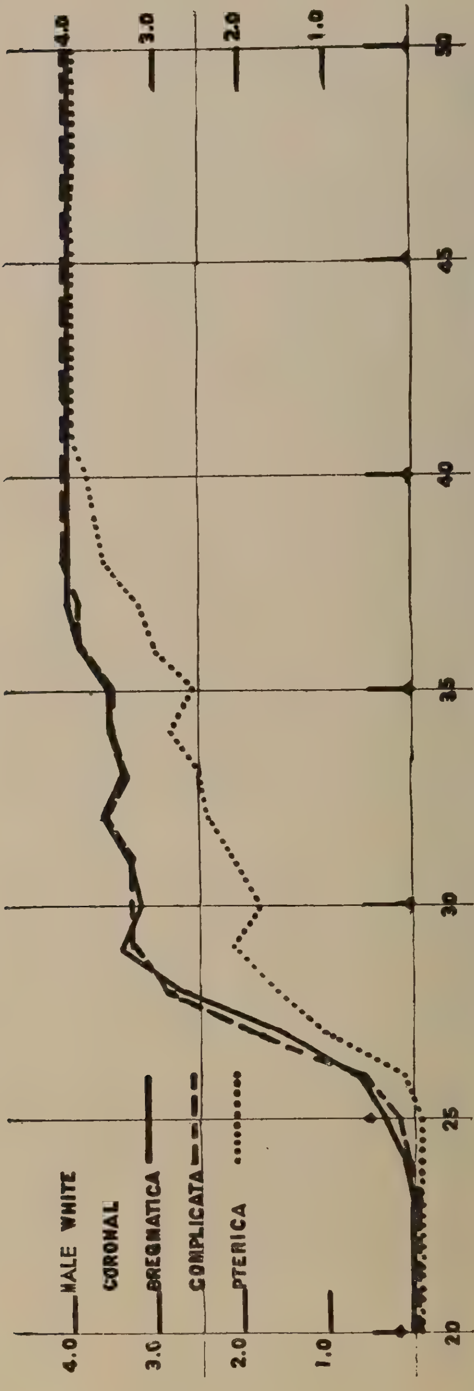

FIG. 3. Endocranial closure progress in the coronal suture. The pars pterica has a special closure progress dictated by its position in the cranium.

The table of closure is the following:—

Age	Period	Number of skulls	
		Retained	Rejected
18–23	pre–(a)	9	1
24–28	(a)+(b)	14	5
29–37	(c)	46	7
38–84	(d)	198	27

Percentage of discards (a)–(c) inclusive on total of these periods............ 16.7

The critical period of closure (a)—(c) of the coronal suture is represented in the collection by 72 skulls of which 12 are rejected as abmodal. The extent of deviation of all discards under thirty-five years has already been shown so that we have now only to note the condition of the four rejected specimens between thirty-five and thirty-seven years.

The state of closure of the sutures in these specimens may be read at a glance from the following tabulation.

Age. 35	No. 242.	Sagittal 0000;	Coronal	R. 243 L. 244	; Lambdoid	R. 000 L. 000 .
Age 36.	No. 445.	Sagittal 4242;	Coronal	R. 443 L. 444	; Lambdoid	R. 100 L. 000 .
	No. 767.	Sagittal 0000;	Coronal	R. 021 L. 022	; Lambdoid	R. 030 L. 043 .
Age 37.	No. 385.	Sagittal 0144;	Coronal	R. 000 L. 033	; Lambdoid	R. 000 L. 000 .

Compared with the usual sequence and times of closure there is sufficient irregularity in each of these to justify its exclusion.

It is at once apparent that irregularities in closure of the coronal suture, while obvious enough, are not so striking as in the sagittal and lambdoid sutures. The condition of the upper part of the suture tends to approximate to the degree of closure in the bregmatic part of the sagittal but this is only a general tendency. The trend of the coronal suture is towards delayed union rather than in the direction of precocious closure. Among his 1820 juvenile crania Bolk found premature obliteration of the coronal suture only twelve times against seventy-one instances for the sagittal.

The simplicity in pattern of the endocranial aspect of the coronal suture is very striking when the complexity of the ectocranial aspect is borne in mind. Into this question we do not propose to enter in this paper. The problem has been discussed by various authors and with their conclusions we shall deal upon another occasion. At the moment it must be impressed upon the reader that the degree of ectocranial complexity upon which the suture is subdivided into its three constituent parts is of no significance for endocranial closure. One must dissociate these two problems for it is sufficiently apparent from our graphs that the bregmatic and complicated parts of the suture are really closely related in their endocranial closure whereas the pars pterica forms a part of another system of suture union with which we shall deal later.

The sixty modal crania comprised in the critical period of union form a singularly harmonious group. The regularity of their closure progress on the endocranial side in spite of the marked difference in ectocranial pattern between bregmatic and complicated portions (Fig. 3), and the symmetry in closure of the two sides are apparent from the preliminary analytic graphs (not published). The right side, if anything, lags a few months behind the left but it would not be wise to lay any stress upon the very slight differences in these curves. Again the bregmatic and complicated portions present almost the same pattern in their closure curves, the one being practically superposed upon the other.

These facts may be presented in the following manner:—

Pars.	Side	Closure commences at	Closure completed at
Bregmatica	Right	24	37
"	Left	24	37
Complicata	Right	24	38
"	Left	24	36

ENDOCRANIAL CLOSURE OF THE PTERIC PART OF THE CORONAL SUTURE

We have already sought to justify exclusion of the pteric part in our consideration of the major part of the coronal suture. The reasonableness of this action will become more and more apparent as the discussion proceeds. But for symmetry of presentation the facts concerning the pars pterica should be stated at once.

Closure commences at twenty-six years with a fairly sharp rise until twenty-nine when the curve begins to climb more gradually. At this age the curve stands at 2.1. Barring a few oscillations the rise after this age, though slower, is fairly steady until complete closure is attained at forty-one. Reference to the graph (Fig. 3) will render more obvious the lagging of closure in this part of the suture behind that of the complicated and bregmatic regions. Its precise significance will receive attention later.

A summary of the facts may be presented thus:—

Male White endocranial coronal closure (pteric part) commences at twenty-six with
- (a) a fairly sharp rise to twenty-nine, after which
- (b) a more gradual but still steady rise to
- (c) complete closure at forty-one.

Age	Period	Number of skulls			
		Retained		Rejected	
18–25	pre–(a)	15		2	
26–28	(a)	8	85	4	21
29–40	(b)	77		17	
41–84	(c)	167		17	

Percentage of discards (a)+(b) on total of these periods.................. 19.8

The chief difference between closure of this part of the suture and closure of the other parts is the delay in commencement and in completion. It seems as though some factor begins at twenty-nine to exert a retarding action upon union throughout the entire suture and since, at this age, the pterica is already behind the other two it remains laggard in its progress. It would be exceedingly difficult to understand this delay both in commencement and in completion if the pars pterica were considered apart from closure in the cranial sutures as a whole. Later on in this presentation it will become apparent that this delay is not an accidental character but falls exactly into line with the closure progress of a suture complex other than that to which the upper part of the suture belongs.

There seems to be some evidence, not however very assuring, that union commences on the right side rather earlier than on the left but in spite of a tendency towards somewhat earlier completion on the right, this advantage constantly passes from one side to the other. We incline therefore to regard the evidence as equivocal and to consider closure progress as symmetrical.

THE LAMBDOID SUTURE

(Figs. 1 and 4)

The lambdoid, according to the graph of the entire suture, closes later than either the sagittal or coronal and this delay is appreciable throughout its course from commencement to completion. There is in this graph no indication of cephalic index. The discussion of a possible relation of shape of skull to suture closure awaits complete presentation of the data for closure in general. Gratiolet described the order of union as sagittal, lambdoid, coronal. He was opposed by Cruveilhier and

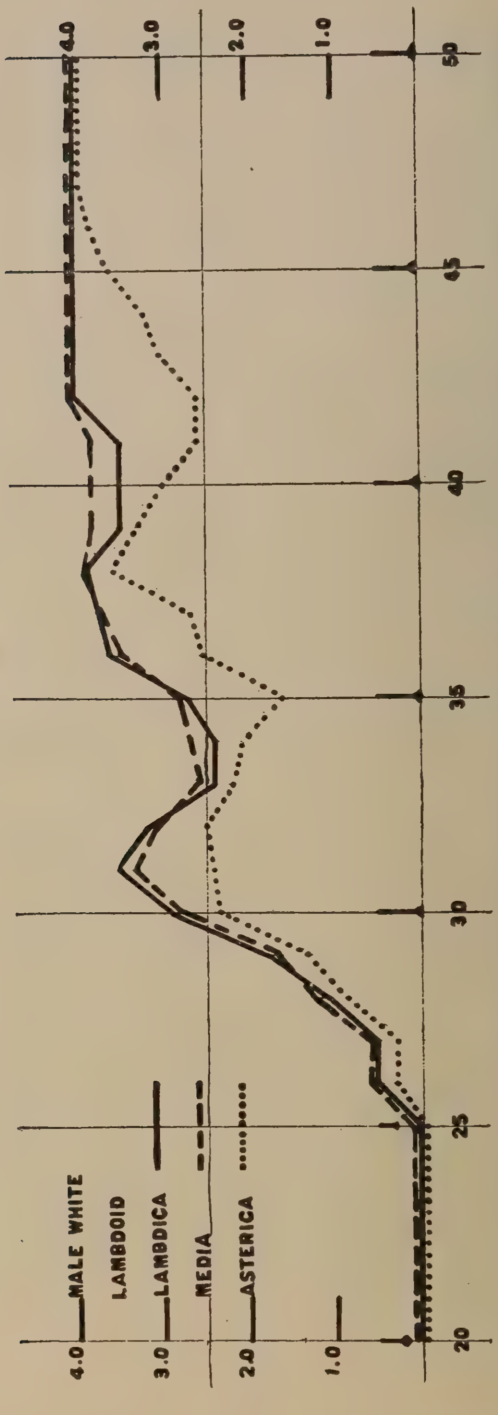

FIG. 4. Endocranial closure progress in the lambdoid suture. All parts show a period of great activity between twenty-six and thirty years. A noteworthy lethargy is exhibited after this phase.

Sappey according to whom the coronal unites before the lambdoid. Meckel and Pommerol also agreed that the coronal closes first. Ribbe objected that Pommerol's cases were too few to justify any conclusion, and himself stated the order for Parisians as sagittal, lambdoid, coronal. Ribbe also allows that the coronal is involved before the lambdoid in one out of three cases. Frédéric found the lambdoid to unite internally after the coronal, the pars media even closing before the pars lambdica. Parsons and Box believe that the lambdoid closes later than the coronal as a rule. All these observations except Frédéric's are based upon the ectocranial sutures, a problem more complex than that of the endocranial aspect. Our graphs (Fig. 1) show that there is little difference in the age relationship of union in the two sutures but that on the moving average the coronal suture does unite before the lambdoid. There are however stages where both curves reach the same point. I have previously shown how inadequate is the general graph to indicate the real course of closure and how actually misleading it may be. The real comparison should be made between the analytic graphs of the two sutures.

The actual differences in closure between the coronal and lambdoid sutures lie in certain facts. In the coronal the pars pterica has a closure progress different from that of the other parts of the suture. This, averaged in the entire suture, drags down the curve. In the lambdoid all three parts are in fairly close harmony up to thirty years. Beyond this date all are delayed and erratic, the pars asterica more than the other two (Fig. 4). The assertion that the lambdoid may close before the coronal does not hold for the endocranial aspect and it is only when the pars pterica is averaged in with the rest of the coronal that there might be any confusion regarding which suture exhibits the greater degree of closure. In coming to this conclusion one must of course discount lapsed union which occurs not infrequently in the pars lambdica. It is largely due to the failure to recognize this condition of lapsed union that previous workers have become confused in their interpretation of the order in suture closure.

At this point one must say a word regarding the fundamental difference between the investigations now being presented and those which have gone before. Until we gathered the accurately dated material in the Hamann Museum no one possessed a sufficient collection of skulls of known age to justify the interpretation of suture closure upon its age relationship. That this is possible for us is due to the fact that we have been able, in addition to the actual age records, to secure internal evidence upon other parts of the skeleton which convinces us that we are in reality dealing with a problem soluble only upon age characters.

In the researches of earlier investigators the age relationship could not be relied upon. There was therefore nothing to fall back upon except the average closure over a large number of adult crania of unknown age. This method naturally involved the concept of a closure tendency. Some sutures or certain parts of sutures show, in the mind of investigators, a greater tendency to close than others. It is easily seen that once the idea of a closure tendency is adopted the alternative concept of an age relationship recedes further in the mental picture until it becomes negligible. Add to this fundamentally erroneous idea the fact that no modal progress could be constructed upon a basis of closure tendency and also the fact that no thought of the problem of lapsed union entered the mind of previous workers and all the elements for complete confusion confront the investigator. Thus our predecessors found themselves entirely at the mercy of a meaningless closure average which must vary with every collection of crania.

From the foregoing statements it is apparent that no effective use can be made of the facts culled and deductions drawn by earlier workers. We should only confuse the reader were we to present and discuss individually the observations which others have made. Should reference to these be desired it can be readily obtained by studying the writings of Frédéric, Ribbe and Pommerol. We shall make only infrequent allusions to these earlier efforts in succeeding pages.

In 1895 Pearson, discussing the value of the mortality curve in enabling one to localize the time and manner of selection, points out the difficulty in separating the effects of growth from those of selection upon the basis of our present knowledge (14). It is precisely this same difficulty which we are attempting to reduce by ascertaining what exactly are the effects of growth and of differentiation in the normal body. Only when this is done shall we be in a position to discuss selection adequately. Hence the fundamental importance of investigating the most readily obtainable part of the body, namely the skeleton, from the standpoint of age. Pearson further points out the salient fact that, with few exceptions, Man is the only form of life whose age at death is known. But as I have shown for the symphysis pubis, as Graves has indicated for the scapula and as Stevenson has demonstrated for epiphysial union, there is another standard by which we may gauge comparable ages throughout the mammalian class including Man. This does not involve years of life but depends upon comparable progress in skeletal growth and differentiation. With this discriminative balance ready to hand, a balance constantly becoming more delicate as we accumulate the necessary facts, biologists and anthropologists will find themselves enabled to weigh evolutionary problems which hitherto have defied all attempts at solution. The question of the cranial sutures is one of the most important pieces of evidence which can be thrown into this biological balance.

The striking feature of closure in the lambdoid suture is the long delay in the final stages of union (Fig. 4). Something of the same character appears in both the sagittal and the coronal sutures, more in the latter than in the former, but the delay in these is nothing like so great as in the lambdoid. Once again the upper two parts run a parallel course as in the coronal suture. The third or pars asterica, though following the others closely until thirty years, maintains a rather independent course thereafter. The distinction is not so marked as in the coronal suture but this is largely due to the curious terminal delay in the partes lambdica and media.

The actual facts regarding closure of the lambdic and medial segments may be thus summarized:—

Male White endocranial lambdoid closure commences at twenty-six years with

(a) a sharply maintained rise to 3.4 at thirty-one, after which it
(b) progresses slowly and irregularly to
(c) complete union at forty-two years.

Age	Period	Number of skulls	
		Retained	Rejected
18–25	pre–(a)	15	2
26–30	(a)	16	6
31–41	(b)	72	15
42–84	(c)	164	17

Percentage of discards (a)—(b) inclusive on total of these periods.......... 19.3

The analytic curves (Fig. 4) show a remarkable regularity of general progress on both sides and in both parts. Commencement of closure occurs in both pars lambdoidea and pars media at twenty-six and final closure takes place uniformly at forty-two. The curious terminal delay cannot be explained at this stage of the presentation. Its elucidation will be clarified in our later work. The course of the curve is not due to a distribution of wholly patent and completely united sutures; there is tremendous variability in the extent of union in different crania during the period (b). In this respect the pars media compares well with the pars lambdoidea; it does not actually precede the lambdoidea in its progress as maintained by some previous workers.

ENDOCRANIAL CLOSURE OF THE PARS ASTERICA OF THE LAMBDOID SUTURE

As in the coronal suture we have segregated the third segment, namely the pars asterica of the lambdoid which also shows a considerable delay in progress of union compared with the rest of the suture. In brief the facts may be stated as follows:—

Male White endocranial lambdoid closure (pars asterica alone) commences at twenty-six years with

(a) an increasingly steep and fairly steady rise to 2.2 at thirty, when

(b) the curve progresses more slowly and much more erratically to

(c) complete closure at forty-seven years.

Age	Period	Number of skulls	
		Retained	Rejected
18–25	pre–(a)	15	2
26–29	(a)	10	5
30–46	(b)	109	.22
47–84	(c)	133	11

Percentage of discards (a+b) on total of these periods.................. 18.5

THE DISCARDS OF THE SECOND HALF OF THE LIFE SPAN

The thirteen crania up to and including the age of thirty-seven years showing an abmodal progress of suture closure have already received attention. There are still twenty-seven crania of thirty-eight years and over which do not fit in with the modal course of suture union. It is convenient to consider these together and they are therefore gathered together at the end of this section. The irregularities shown are very diverse in nature. Sometimes only a segment or two of a single suture present anomalies of closure. Sometimes the irregularity is more widely spread. In certain crania the sagittal and lambdoid sutures are at fault, sometimes the coronal and lambdoid. No crania have been withheld solely on account of lapsed union although there are such specimens in this group of abmodal crania. Instances of lapsed union are marked with an asterisk (*). A few crania showed only a slight and localized abmodality and in each this was weighed very carefully before the skull was dismissed from the typical series. In every instance it was felt that, however slight the anomaly might seem to be, accuracy required that for the present at least the cranium should be eliminated.

The formulae show that delayed union is the main cause of rejection and this delay is more marked in the lambdoid suture than in the other two. This is quite in accordance with the fact that union in the lambdoid is normally later than in the sagittal and coronal. We shall see further on that extravagant lethargy in closure of the lambdoid is even more marked in the Negro series and results in the rejection of a much greater proportion of Negro skulls. I am convinced that much of the confusion in previous examinations of suture closure has been caused by the irregularity of lambdoid closure the explanation of which cannot be attempted at this stage.

R. 333 R. 334
Age 38. No. 480. Sagittal 4444; Coronal ; Lambdoid .
L. 444 L. 333
R. 000 R. 420
No. 581. Sagittal 4444; Coronal ; Lambdoid .
L. 000 L. 110
R. 000 R. 000
No. 801. Sagittal 0242; Coronal ; Lambdoid .
L. 000 L. 000
R. 044 R. 310
Age 39. No. 550. Sagittal 2244; Coronal ; Lambdoid .
L. 020 L. 110
R. 430 R. 000
No. 892. Sagittal 4143; Coronal ; Lambdoid .
L. 440 L. 000
R. 243 R. 000
Age 40. No. 351. Sagittal 0010; Coronal ; Lambdoid .
L. 243 L. 000
R. 010 R. 000
No. 619. Sagittal 0140; Coronal ; Lambdoid .
L. 020 L. 000
R. 444 R. 000
No. 740. Sagittal 4444; Coronal ; Lambdoid .
L. 444 L. 000
R. 343 R. 444
No. 772. Sagittal 4444; Coronal ; Lambdoid .
L. 343 L. 444
R. 444 R. 330
No. 952. Sagittal 4444; Coronal ; Lambdoid .
L. 344 L. 320
R. 000 R. 010
Age 44. No. 819. Sagittal 4334; Coronal ; Lambdoid .
L. 000 L. 000
R. 444 R. 400
Age 45. No. 320. Sagittal 43*43*; Coronal ; Lambdoid .
L. 444 L. 400
R. 444 R. 030
No. 395. Sagittal 43*44; Coronal ; Lambdoid
L. 444 L. 020
R. 000 R. 3*42
No. 689. Sagittal 42*44; Coronal ; Lambdoid .
L. 033 L. 440

Age 46.	No. 188.	Sagittal 4444;	Coronal	R. 444 L. 444	; Lambdoid	R. 000 L. 000.
	No. 352.	Sagittal 0444;	Coronal	R. 343 L. 444	; Lambdoid	R. 0*43 L. 0*43.
Age 47.	No. 701.	Sagittal 3100;	Coronal	R. 034 L. 044	; Lambdoid	R. 440 L. 431.
Age 48.	No. 213.	Sagittal 3100;	Coronal	R. 000 L. 100	; Lambdoid	R. 233 L. 230.
	No. 332.	Sagittal 4444;	Coronal	R. 444 L. 444	; Lambdoid	R. 200 L. 000.
Age 50.	No. 183.	Sagittal 0342;	Coronal	R. 000 L. 000	; Lambdoid	R. 000 L. 000.
	No. 758.	Sagittal 0000;	Coronal	R. 040 L. 000	; Lambdoid	R. 000 L. 000.
	No. 768.	Sagittal 43*44;	Coronal	R. 110 L. 110	; Lambdoid	R. 100 L. 110.
Age 51.	No. 96.	Sagittal 0444;	Coronal	R. 44? L. 00?	; Lambdoid	R. 440 L. 443.
Age 52.	No. 890.	Sagittal 4444;	Coronal	R. 320 L. 320	; Lambdoid	R. 2*20 L. 1*30.
Age 53.	No. 325.	Sagittal 4444;	Coronal	R. 443 L. 440	; Lambdoid	R. 3*40 L. 0*00.
Age 55.	No. 384.	Sagittal 4443*;	Coronal	R. 443 L. 443	; Lambdoid	R. 3*40 L. 3*00.
Age 56.	No. 393.	Sagittal 4444;	Coronal	R. 3*40 L. 3*40	; Lambdoid	R. 420 L. 240.

GENERAL OBSERVATIONS UPON CLOSURE OF THE VAULT SUTURES

In the foregoing pages we have learned the method of scrutinizing our material and the details of closure progress for each part of the three sutures of the vault. We have now to observe that upon these data there begins to take form an altogether new conception of what suture closure progress implies, a conception which permits a comparison at once with other races and with other mammals and brings into their true perspective very important phenomena of suture union.

The general graphs (Fig. 1) indicate that for White males union as a rule begins in the order, sagittal, coronal and lambdoid. They show that the progress in closure occurs in the same order and that the curves of progress of these successive sutures never actually cross each other. Whereas union commences in the sagittal at twenty-three (twenty-two for the obelica) its beginning is delayed in the coronal until twenty-four and in the lambdoid until twenty-six. This is a fairly rapid succession compared with the ages of completed union for in the sagittal closure is perfected at thirty-five but in the coronal not until forty-one and in the lambdoid it does not occur until forty-seven years. A curious fact, and as we shall presently see, a very significant one, is that there is a period of great activity in union progress during the latter half of the third decade. The great slowing up of closure only occurs after this when the sutures are already three-quarters united.

We now turn to the analytic graphs (Figs 2, 3, 4). The third part of each suture (obelica, pterica, asterica) has a progress more or less independent of that of the remainder of the suture. The obelica has a very short period of initial delay and then climbs steadily to complete union without any terminal prolongation. The age at which union is complete, namely twenty-nine years, is the beginning of a quite significant period in the history of the cranium and of the skeleton in general. The pterica and to a less extent the asterica, though commencing to close with or soon after the remainder of the coronal and lambdoid sutures respectively and continuing with them until twenty-nine or thirty years, exhibit thereafter obvious lagging, the precise significance of which cannot at the moment be explained.

The remaining parts of each suture, at whatever age they may commence to unite, present an initial period of laggard progress but at twenty-six or twenty-seven years the curves of all shoot up steadily and reach a varying degree of union by the age of thirty years or thereabouts when slowing up of the progress again makes itself evident. One must class these sutural elements together and differentiate them from the segments already discussed. The true sutures of the vault are not the sagittal, coronal and lambdoid in their entirety but these three sutures with the pterica and asterica omitted. The obelica is a law to itself and the pars verticis in its slowing up at twenty-nine, ahead of the other elements, shows unmistakably the influence of its neighbor the obelica.

The second fact which emerges at this juncture from our study is the definiteness of suture union as a feature of the age period between twenty-six and thirty years, that is to say the last stage of skeletal growth. This period, following immediately upon the completion of union of all epiphyses, is readily recognizable in all mammalian skeletons and its real significance becomes clear in our subsequent comparative studies.

It is very interesting, though we do not yet know how important, that by the age of twenty-nine the extent of closure in all these true sutural elements of the vault has reached a little more than three-quarters of their entire extent (about 3.4, see Figs 2, 3, 4). The slowing up of the pterica and asterica, which takes place at about the same age, finds these elements united to about half their entire extent (about 2.2). It is true that the sagittal progresses a fraction more by thirty-one. This is probably because the influence bringing about the slowing up does not act suddenly but arrests further activity between the ages of twenty-nine and thirty-one, namely the period at which the skeleton as a whole becomes stationary on reaching the completely adult condition. That there is some influence at work is certain for all the sutural elements, whatever their degree of union, show arrested activity at the same age. Is it not possible that we have here evidence of the final stage in general skeletal growth with the ultimate petering out of activity and the settling down of the skeleton into a quiescent adult condition at thirty years. If we may adopt this view, and subsequent presentation of our comparative studies will show how reasonable it is, then we have a criterion for judging of comparative values in suture closure. For the present we shall consider that the later years of the third decade in Man represent a definite period in the history of sutural closure.

THE CIRCUM-MEATAL SUTURES

(Fig. 5)

The next group of sutures is one centering upon the external auditory meatus. They are, in order from before backwards, sphenotemporal inferior and superior; squamous anterior and posterior; parieto-mastoid; masto-occipital superior, middle and inferior. Abutting upon this almost circular succession of sutures are the asterica of the lambdoid and, through the spheno-parietal, the pterica of the coronal. Before considering these sutures in detail it is well to recall that there is a period of great activity in suture closure between the twenty-sixth and thirtieth years shown in all the sutures of the vault. Whatever the time when union first begins in the vault sutures, closure progresses only slowly until twenty-six years, and after the acceleration between twenty-six and thirty closure progress again slows down quite independently of the degree of union attained by that date.

The spheno-temporal and masto-occipital sutures, like the coronal and lambdoid, extend from the medial region of the cranium laterally, ultimately throwing themselves into the purely lateral squamous and parieto-mastoid sutures. These relations to the contour of the cranium will be found to be of the utmost significance.

No eliminations have been carried out on the basis of this group of sutures. In spite of the fact that Bolk found premature union far more common in the masto-occipital than in any other suture, namely 272 times in 1820 juvenile skulls, we have not discovered any such proportion. Bolk of course was dealing with the ectocranial sutures but even there we do not find a large proportion of premature union in the masto-occipital. So little being known concerning suture closure in this group and the actual progress illustrated by our preliminary graphs being so much less regular than in the vault sutures we have felt it advisable to carry out our eliminations upon a basis of the vault sutures alone. As a matter of fact a study of the discards shows in two only of the forty abmodal crania a real difference between the character of the masto-occipital sutures and that of the vault sutures. No. 653, of age twenty-six, exhibits a retarded condition of the vault sutures but an erratically accelerated union in the masto-occipital sutures. No. 242, of age thirty-five, presents a retarded condition of the vault and an erratically retarded appearance of the masto-occipital. The other discards show no anomaly of the circum-meatal sutures. We have however rejected them from all final graphs upon the basis of their vault sutures so as to obtain a consistent series.

The swinging course of the closure curves in these circummeatal sutures is undoubtedly due to the relative paucity of material for certain ages. With a much larger series, even with the addition of the forty rejects, the curves would have been more regular in their course.

THE MASTO-OCCIPITAL SUTURE

(Fig. 5.)

The masto-occipital suture finds a more or less natural subdivision into three parts and this subdivision we have followed. It is apparent however that, as in the case of the coronal and lambdoid sutures, the first and second parts cannot well be separated in their closure whereas

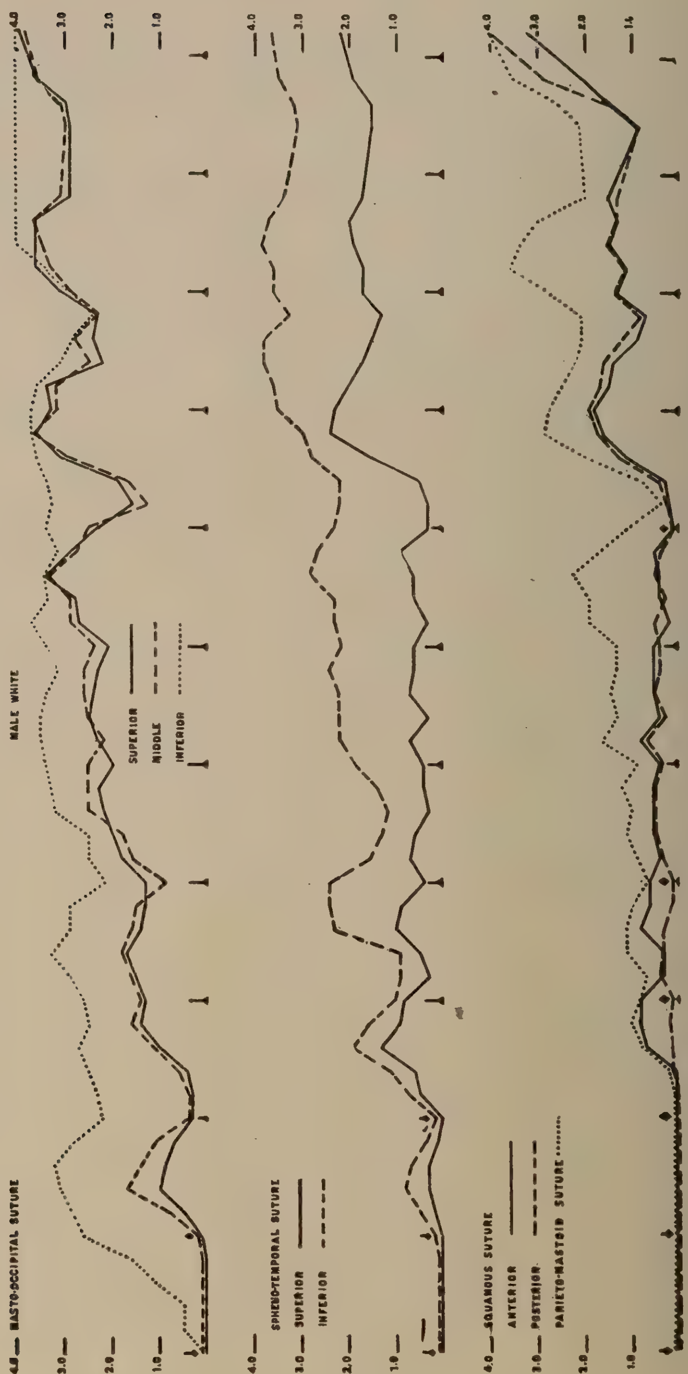

FIG. 5. Endocranial closure progress in the circum-meatal sutures. The progress in all these except the third (inferior) part of the masto-occipital suture is obviously different from the closure pattern of the vault sutures.

the third or pars inferior falls into a category by itself (Fig. 5). In our presentation of the facts we shall therefore treat the third part separately from the other two.

SUPERIOR AND MIDDLE PARTS

Closure commences in the superior and middle parts of the suture at thirty years and by thirty-two has reached an average of 1.25. At this level the curve remains fairly steady, barring oscillations, until forty-six. At this age slow progress is again made and continues until sixty-four when a second period of relative inactivity begins at about 3.5, studded with oscillatory movements of the curve, and is terminated by the climbing of the curve to 4.0 at eighty-one years. The peculiarity of this curve of closure brings to mind certain facts already ascertained in the study of other sutures. The appearance of the retarding influence at thirty-two is to be expected. Between forty-two and forty-seven years union is completed in the lambdoid suture which is of course neighbor to the masto-occipital. After sixty-four the inactivity which we find to be characteristic of other circum-meatal sutures is apparent here also. And again the final burst of energy at eighty-one is evident. I do not desire to make too much of these similarities at this point in the discussion but wish to draw the reader's attention to them in passing.

The facts regarding closure of the partes superior and media may be stated in the following manner:—

Male White endocranial masto-occipital closure commences at thirty years with

(a) a short period of activity resulting in a rise to about 1.25 at thirty-two, when the condition becomes practically stationary until forty-five.

(b) from forty-six until sixty-four there is a period of renewed activity, the curve rising erratically to 3.5, after which

(c) a second period of relative quiescence supervenes, broken by

(d) a final burst of activity at eighty-one years.

Age	Period	Number of skulls	
		Retained	Rejected
18–29	pre–(a)	25	7
30–45	(a)	106	20
46–63	(b)	94	13
64–80	(c)	39	0
81–84	(d)	3	0

Percentage of discards (a)—(c) inclusive in total of this period............ 13.8

THE MASTO-OCCIPITAL SUTURE (PARS INFERIOR)

Closure of the inferior part of the masto-occipital suture commences at twenty-six, four years earlier than in the remainder of the suture but at the same age as in the lambdoid. It progresses rapidly until thirty when it begins to slow down. Having reached 3.2 at thirty-three the curve remains at this level until forty-eight. After this age the curve oscillates round 3.5 until seventy-two years when complete closure is attained. There is really no great difference in this record from that of the superior and middle parts of the suture where thirty-two and forty-six years are significant dates. The final completion of union however occurs a decade earlier.

The ensuing table gives the facts briefly.

Male White endocranial masto-occipital (inferior) closure commences at twenty-six and
(a) gathers speed rapidly until thirty years when
(b) the curve of union becomes retarded about the point 3.2 until forty-nine when
(c) a period of slow progress sets in anew, resulting in a rise to 3.5, continuing at this level until seventy-two, when
(d) a final spurt of activity carries it to complete union.

Age	Period	Number of skulls	
		Retained	Rejected
18–25	pre-(a)	15	2
26–29	(a)	10	5
30–48	(b)	120	25
49–71	(c)	109	8
72–84	(b)	13	0

Percentage of discards (a)–(c) inclusive on total of this period.............. 13.4

The most striking feature of union progress in the masto-occipital suture is the attempt of the third part to follow the type illustrated by the vault sutures. There is the same accelerated progress between twenty-six and thirty years and the same slowing down about that date. The upper parts of the coronal and lambdoid have reached the point 3.4 when stagnation sets in; the inferior masto-occipital has attained 3.2 when slowing takes place.

The superior and middle parts have barely commenced to close when they begin to feel the effect of the retarding influence so strongly marked in the other sutures already discussed. This influence is inhibitory but not prohibitory for union continues to progress but much more slowly. It is the almost imperceptible progress after the inhibitory influence has become effective that will, before long, be found to be the characteristic of closure in sutures which have broken away in their time relationship from the typical mammalian form. Later on we shall be able to discuss this curious phenomenon in greater detail. It occurs in each suture of the circum-meatal group.

The final stage of closure of the inferior masto-occipital suture is very long drawn out, and that it is certainly completed at seventy-two and not earlier would be difficult to assert. Later we shall see that there is a close parallel between the final stage in this suture and the final stage of closure in the spheno-frontal which however terminates at sixty-four. The difference in time between the actual dates of complete union in these two sutures must not be allowed to obscure the very close harmony apparent in the general course of their closure curves.

THE SPHENO-TEMPORAL SUTURE

(Fig. 5.)

There is a distinct advantage in subdividing the spheno-temporal suture into superior and inferior parts for our investigation shows that the restraining influence affects in different degree the closure of the two parts (Fig. 5).

THE INFERIOR PART

Closure in the inferior part first makes its appearance at thirty years and, showing clearly the effect of inhibition, progresses very slowly until sixty-seven when the maximum union of 3.9 is attained. For practical purposes the suture is now completely united. The period between thirty and sixty-seven is naturally marked by oscillations of the curve but with a very much larger series one would be justified in expecting these oscillations to rule themselves out. The fact that closure is never quite complete is fully in harmony with the remarkably slow progress of union in this suture.

Age	Period	Number of skulls	
		Retained	Rejected
18–29	pre–(a)	25	7
30–66	(a)	205	33
67–84	(b)	37	0

Percentage of discards (a) on total of this period........................ 12.0

SUPERIOR PART

Closure in the superior part of the spheno-temporal suture makes its earliest appearance at thirty-one, practically the same age as beginning closure in the inferior portion. But unlike the process in the latter segment progress is more definitely restrained and no further closure takes place until the age of sixty-three when there is a sudden burst of energy which carries union up to 2.4, its maximum, at sixty-four. Beyond this age there are oscillations as there are between thirty-one and sixty-two but on the whole no further progress is made. As in other sutures it is impossible to avoid the impression that some delaying influence begins to be felt at about the age of thirty.

Age	Period	Number of skulls	
		Retained	Rejected
18–30	pre–(a)	31	8
31–62	(a)	187	32
63	(s)	7	0
64–84	(c)	42	0

Percentage of discards (a+b) on total of this period...................... 11.9

We have already seen that the third part of the masto-occipital suture reproduces in the main the features of closure exhibited in the upper parts of the coronal and lambdoid sutures, whereas the superior and middle parts of the masto-occipital suture present a new type of closure progress. We now observe that the inferior part of the spheno-temporal suture reproduces the features of closure progress seen in the upper part of the masto-occipital. The superior spheno-temporal on the other hand shows a further deviation from the type common to all the vault sutures. There is practically no union at all until comparatively late in life. It is not until sixty-three years that closure becomes well marked and it is noteworthy that this age is one at which there is generally a spurt of activity recognizable clearly in other sutures also.

THE SQUAMOUS SUTURE

(Fig. 5.)

As a precautionary measure we have subdivided the squamous suture into anterior and posterior parts as was done by previous workers but our examination demonstrates that there is no real advantage to be gained from this arrangement. A glance at the graph (Fig. 5) illustrates this quite clearly. Consequently we shall not regard the subdivision except in the final analysis.

A slight degree of closure appears in (the posterior part first of) this suture at thirty-seven years but, apart from oscillations, never progresses beyond 0.5 until sixty-two when there is a renewed activity and the curve of closure rises sharply to about 1.75. There now follows a second period of stagnation until seventy-nine years when activity again appears and the maximum union is attained at eighty-one. This maximum is 4.0 or complete closure for the posterior part but only 3.2 for the anterior.

In the analysis one finds that closure begins in the anterior part on both sides at thirty-eight and is never complete. In the posterior part it commences on both sides at thirty-seven, terminating in complete union beyond eighty-one if ever.

Age	Period	Number of skulls	
		Retained	Rejected
18–36	pre–(a)	67	12
37–61	(a)	150	28
62–64	(b)	11	0
65–78	(c)	35	0
79–80	(d)	1	0
81–84	(e)	3	0

Percentages of discards (a)–(d) inclusive on total of this period, ... 12.3

THE PARIETO-MASTOID SUTURE

(Fig. 5)

Closure in the parieto-mastoid suture follows very closely the progress of union in the squamous suture of which it may almost be considered a continuation (Fig. 5).

The first appearance of union occurs at thirty-seven years though little progress is made until the age of fifty-one. After this the curve shows greater oscillations but on the whole is somewhat speeded up in rate and complete union is attained at eighty-one as in the posterior squamous. It is possible, though our records do not definitely show it, that this suture participates in the increased activity apparent in the squamous at about sixty-two. But since the records are equivocal upon this point it is at least impossible to assert that closure steadily progresses as in the inferior spheno-temporal suture.

Age	Period	Number of skulls	
		Retained	Rejected
18–36	pre–(a)	67	12
37–80	(a)	197	28
81–84	(b)	3	0

Percentage of discards (a) on total of this period 12.3

GENERAL REVIEW OF CIRCUM-MEATAL CLOSURE

It is now possible to make a general survey of the features of closure progress in the circum-meatal group. It differs in all more or less markedly from the type pattern of progress as exhibited by the vault sutures. We shall refer to this condition as emancipation in various degree.

Of the several sutures the squamous exhibits emancipation in highest degree. In it there is no closure at all worth consideration until sixty-three years when the curve runs up sharply to about 1.75. After this burst there is no further activity in the anterior part until the later spurt commencing about seventy-nine which carries the curve to 3.2 by eighty-one years. In the posterior part emancipation is not so well maintained for the last period of activity in old age brings the curve up to 4.0, namely complete union.

The parieto-mastoid suture, though following fairly closely the closure pattern of the squamous, presents features intermediate between those of the superior and inferior spheno-temporal sutures, resembling indeed the former more than the latter. As in the case of the squamous the initial start is delayed till the end of the fourth decade but more progress is made after fifty-one years. From this time on a slightly increased rate is maintained which ultimately results in complete union. Hence in later life the progress of the parieto-mastoid suture is more like that of the inferior spheno-temporal suture. In middle life its closure pattern resembles that of the superior spheno-temporal and the squamous.

The superior spheno-temporal suture gets a rather earlier start than the squamous though it is doubtful if this should receive much weight since it is so badly maintained. Once it has started the features of the curve are very like those of the squamous and it participates in the renewed activity of the earlier years of the seventh decade.

The inferior spheno-temporal and the superior and middle parts of the masto-occipital run almost parallel courses which have been sufficiently indicated. The inferior masto-occipital shows the least degree of emancipation from the type pattern of the vault sutures.

Now, if the curves for the pterica of the coronal, the asterica of the lambdoid and the inferior masto-occipital be compared it will be seen that they form a graded sequence in emancipation from the true vault suture closure pattern. We may then establish a sequence in emancipation showing the lowest grade in the coronal pterica and the highest in the anterior squamous. The order of emancipation is the following:—

Coronal pterica; lambdoid asterica; inferior masto-occipital; superior and middle masto-occipital and inferior spheno-temporal; parieto-mastoid; superior spheno-temporal; posterior squamous; anterior squamous.

SIGNIFICANCE OF THE DISCARDS

It has already been stated that the discards have been rejected upon the basis of their vault suture progress alone. That there should be but two crania which could be fairly discarded upon the basis of progress in union of the circum-meatal sutures is an arresting fact and, taken in conjunction with the results of our observations upon the vault, a problem worthy of further study. I have mentioned that, in all sutures the retardation of closure progress commencing about the age of thirty years is an inhibition rather than a prohibition of further closure. There are however certain crania in which further union seems to be permanently inhibited. To this we must return later but its occasional occurrence is a natural extreme degree of the variability induced by the retarding influence.

Table I. Table of Discards—Male White

1 Age period	2 Total	3 Discards	4	5 Remaining in series	6	7 Percentage of discards	8	9
(Decade)		Inclusive of all (A)	Retarded only (B)	Total —col. 3 (A)	Total —col. 4 (B)	Col. 3 to col. 2	Col. 4 to col. 2	Col. 4 to col. 6
10–19 (2nd)	2	0	0	2	2			
20–29 (3rd)	30	7	4	23	26	23.3	13.3	15.4
30–39 (4th)	67	11	9	56	58	16.3	13.4	15.5
40–49 (5th)	81	14	10	67	71	17.3	12.3	14.1
50–59 (6th)	61	8	7	53	54	14.7	11.5	13 0
60–69 (7th)	44	0	0	44	44			
70–79 (8th)	19	0	0	19	19			
80–89 (9th)	3	0	0	3	3			
Totals.	307	40	30	267	277	13.3	9.8	10.8

If we refer to the table of discards (Table I) we observe that there is no plain relation between the number of discards and successive age periods (column 7). But if the crania showing accelerated, locally anomalous and erratic closure be discounted, leaving only those discards which exhibit pure retardation, then we find a very significant relationship of discards both to the total number of each age period (column 8) and to the number of modal crania left in each age period (column 9). The discards are all eliminated upon the basis of their vault sutures and the vault sutures all attain complete union during the fourth and fifth decades. During the third and fourth decades the percentage of discards remains stationary but diminishes in the fifth and sixth decades and there are no retarded examples found beyond the latter. We do not here propose to discuss permanently inhibited suture union which we term for convenience the asterisked suture; we refer only to pure retardation.

We have seen by the graphs that retardation setting in about thirty years is merely a slowing down influence and does not result in any permanent prohibition of union. We now see from this table that the discards, eliminated because of retardation in vault closure, exhibit merely delayed union and that eventually their vault sutures would probably all close. We are then observing the effect of an influence which tends to make its presence felt throughout adult life in Man, affects some sutures (the circum-meatal group) more than others (the vault group), and has a specially marked effect appearing quite suddenly at about thirty years. Granting that we are compelled by the facts to concede the existence of a retarding influence, we may expect that certain sutures will exhibit retardation more than others. This has already been demonstrated (page 370). Concerning the cause for the existence of the retarding influence it is rather early in the discussion to build any hypothesis but I consider the retarding influence related to local evolutionary development of the cerebrum.

Turning now to the several lists of discards it becomes evident that retardation is much more marked in the lambdoid than in either of the other vault sutures. As a rule also it is the lower part of the suture which shows retardation most clearly. This means of course that in certain crania the lambdoid suture presents a closure progress resembling more or less closely that of the circum-meatal group. We note this tendency even in the modal course of the lambdoid graphs (Fig. 4). It is by no means to be inferred that the sequence of emancipation in the circum-meatal group is rigidly adhered to, or that I desire to emphasize the several degrees of emancipation. Rather I would explain that there are groupings of sutures which present closure patterns intermediate between the extreme types illustrated by the true vault sutures on the one hand and the squamous on the other. If we start with the squamous itself and follow the suture line backward we are able to note progressively less degrees of emancipation as we trace the parieto-mastoid and then either the lambdoid upward to the lambda or the masto-occipital downward, which latter sutures may be considered as the inverted mirror image each of the other.

It is probably this varying emancipation of the lambdoid suture which has produced confusion in the statements of previous authors regarding early or late closure of the lambdoid suture compared with union of the coronal. It is probably also responsible for the fairly wide-spread belief that there is some relation between the relative date of lambdoid closure and the cephalic index.

THE ACCESSORY SUTURES

(Fig. 6.)

We now pass to the consideration of two sutures which in view of their position, scarcely belong to the circum-meatal group, and more cer-

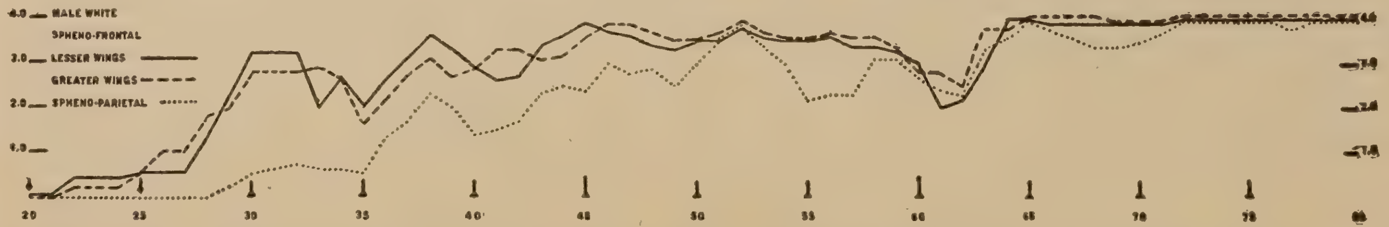

FIG. 6. Endocranial closure progress in the accessory sutures. The pattern of sphenofrontal closure simulates that of the vault sutures whereas that of sphenoparietal closure resembles more closely the pattern of circum-meatal closure.

tainly, by their closure pattern, form no part of the vault series. These are the spheno-parietal and spheno-frontal sutures. As the story of their closure is unravelled it becomes clear that they lie upon the threshold of emancipation and form, as it were, a link between the true vault sutures and the circum-meatal group.

THE SPHENO-PARIETAL SUTURE

(Fig. 6.)

Closure in this suture commences at twenty-nine and, encountering the delaying influence almost at once, progresses quite gradually and with many oscillations until forty-six when the graph has reached the level of 3.0. After this the course of the graph (Fig. 6), is very irregular although there is some slight progress until sixty-four. At sixty-five complete closure is attained as in the spheno-frontal suture. It is true that the graph shows a sagging of the curve beyond this point but I am inclined to regard this as spurious and simply resulting from paucity of material.

The facts briefly are these:—

Closure commences at twenty-nine years and is almost immediately slowed down so that there is a

(a) slow progress to forty-six when the curve stands at 3.0, then
(b) a period of considerable oscillation with little progress to sixty-four,
(c) complete union occurring at sixty-five.

Age	Period	Number of skulls	
		Retained	Rejected
18–28	pre–(a)	23	6
29–45	(a)	108	21
46–64	(b)	97	13
65–84	(c)	39	0

Percentage of discards (a+b) to total of this period.................... 14.2

The type of closure of this suture corresponds very closely with those exhibited by the inferior spheno-temporal and by the superior and middle parts of the masto-occipital. This is the more striking since closure of the spheno-frontal and of the inferior part of the masto-occipital is found to be so harmonious. Closure in the spheno-parietal begins indeed one year earlier than in the upper masto-occipital but in both there are distinct periods between thirty and forty-five, and from forty-six to sixty-four. Both periods are characterized by slow progress, it may be very slow, and the completion of union in the spheno-parietal is balanced by the attainment of the maximum closure in the masto-occipital.

We see therefore lesser stages of emancipation in the several sutures progressively more remote from the focus of emancipation, namely the anterior squamous.

THE SPHENO-FRONTAL SUTURE
(Fig. 6.)

In considering the spheno-frontal suture one cannot help the suggestion that here we have a suture which, like the sagittal and the inferior masto-occipital has only a remote and modified relation to phenomena of cerebral development. One is therefore already prepared to find a graph of the moving average different from those of the other sutures which carry its line backwards.

In the first place the graph (Fig. 6), shows a close parallel between the curves of the two parts so that it becomes unnecessary to treat them separately.

In both parts closure commences at twenty-two and, as usual, makes rather slow progress during the next years. In the region of the greater wings at twenty-five and in that of the lesser wings at twenty-seven the rate of union rapidly increases and by thirty years the curve centers at about 3.0. It is somewhat striking that the speeding up process begins for this suture, as for all the others, about the age of twenty-six. This speeding up is obviously a general characteristic of suture closure and unrelated to particular location. After thirty years there is a long period of oscillation during which union on the whole makes no progress. This ends at sixty-four. At sixty-four the suture of the lesser wings, and at sixty-five that for the greater wings is completely closed.

These facts may be briefly stated in the following manner:—

Closure commences at twenty-two with
- (a) a gradual rise to 0.7 at twenty-six, followed by
- (b) a steeper progress to 3.0 at thirty, when there commences
- (c) a period of oscillation with no further union ending at sixty-four, and resulting in
- (d) complete closure at or about sixty-five.

Age	Period	Number of skulls	
		Retained	Rejected
18–21	pre–(a)	4	0
22–25	(a)	11	2
26–29	(b)	10	5
30–64	(c)	203	33
65–84	(d)	39	0

Percentage of discards (a)–(c) inclusive to total of this period.............. 15.1

Comparison of the graphs of this suture and of the inferior masto-occipital shows a very striking likeness. It is true that closure commences about four years earlier in this suture than in the pars inferior of the masto-occipital but both exhibit the speeding up process about twenty-six, the slowing down at thirty years and the long ensuing period of oscillations without further progress. The similarity only breaks down in old age because of the unexpected, and probably unwarrantable, dip of the graph for the pars inferior in the sixties.

Comparison with the graph of the lambdoid asterica also shows striking similarities. Except for the early start of union in the spheno-frontal, a start which is not at all maintained, union follows an almost parallel course in both these sutures. Indeed the course of closure in the spheno-frontal may more properly be considered intermediate between those of the superior and middle lambdoid on the one hand and the pars asterica on the other. This similarity brings into one group the spheno-frontal, the lambdoid and the inferior masto-occipital, three sutures on the frontiers of the zone of emancipation, the center of which is in the anterior squamous. When one realizes this close similarity the early commencement of union in the spheno-frontal becomes all the more striking. For here on the very edge of emancipatory influence is a suture which begins to close as early as the sagittal, a suture undoubtedly presenting an ancestral stage in the time relationship of its commencing union. In further studies it will be our task to follow the clues given in age relationship of suture closure regarding the ancestral condition of the human closure pattern.

THE PERIODIC CHARACTER OF SUTURE UNION

In studies upon the skeleton, growth and differentiation should be sharply distinguished. The amount of increase in dimensions of a long bone is one thing and the actual union of its epiphyses is another. The two have been regarded as closely related aspects of a single problem. In certain cases of a pathological nature they are completely dissociated. I think it safer not to link them inseparably in normal anatomy until they have been definitely shown to justify this treatment. Actual increase in dimension may not be taking place uniformly throughout the period before actual epiphysical union though there may be, and probably are, continuous alterations in adjustment between epiphysis and diaphysis. This latter is a problem of differentiation, not of growth. Cranial suture closure has probably no very definite relation to cranial growth. Certainly the cranium is not growing in its various parts throughout the life period until union of all the sutures takes place. Suture union is a problem of differentiation rather than of growth.

Having observed the picture of progressive closure as it presents itself in the several sutures we are now in a position to note that the nature of this progress differs greatly in different areas of the cranium. The course of closure in the vault sutures is not at all the same thing as the course in the squamous suture and between these two extremes there are intermediate types of progress related definitely to the particular area of the cranium in which the suture finds itself.

The age relationship in detailed progress of union varies with the suture but in all sutures there is a periodicity of union. We have observed marked activity of progress between the ages of twenty-six and thirty years and sudden diminution of activity immediately thereafter. No matter what stage of union is reached, the suture does not continue to unite so rapidly after thirty years as it did before. But although the period of extreme activity, one might say the typical period of suture union, occurs from twenty-six to thirty, there seem to be subsidiary periods when activity receives a further impetus, and these periods can be traced even into old age. In certain graphs it may indeed be doubted that any impetus can be discerned. Nevertheless in general the curves of union do show periodicity and spurts of increased progress tend to alternate with periods of relative quiescence. I have already demonstrated a similar periodicity in the differentiation (metamorphosis) of the pubic bone (19, 22) after adult life is reached, exhibiting a similar rather poorly defined age relationship. These are the periods of quiescence and secondary changes which are not as yet fully worked out for they do not present the clear cut age relationship characteristic of the earlier phases of pubic differentiation. It is as though Nature grew somewhat tired of regulating precisely the order and date of differentiation and gave more latitude to the individual after middle age. This relatively ill-defined age relationship is characteristic of all features of differentiation during the second half of the life span so far studied in this laboratory. It is only in later communications that I shall be able to lay stress upon this periodicity in differentiation to the extent which it deserves for I recognize that much more evidence from various parts of the skeleton must be presented before its existence and significance can be made clear.

In the present study it is however plain that cranial sutures tend to close with marked vigor between twenty-six and thirty years and there are varying degrees of emancipation from this regulation apparent in certain sutures. The squamous suture shows emancipation in highest degree and the sutures in the vicinity of the squamous exhibit emancipation apparently depending upon the varying relation of their site to the squamous. The spheno-frontal and inferior masto-occipital sutures therefore present curves of closure progress most closely simulating those of the true vault sutures.

In order that the reader may clearly appreciate the complex age relationship and periodicity of suture closure I have drawn up a table giving briefly the outstanding facts (Table II).

TABLE II—CRANIAL SUTURES—MALE WHITE ENDOCRANIAL CLOSURE

Suture	Commencement and course		Termination (or peak)	
Sagittal	22	slow to 26	35	slows at 31 at 3.9
Sphenofrontal lesser w.	22		64	slows at 30 at 3.0 final burst of activity
Sphenofrontal greater w.	22		65	slows at 30 at 3.0 final burst of activity
Coronal 1 and 2	24		38	slows at 29 at 3.4
Coronal 3	26	rapid to ca 30	41	slows at 29 at 2.1
Lambdoid 1 and 2	26		42	slows at 31 at 3.4
Lambdoid 3	26		47	slows at 30 at 2.2
Masto-occipital 3	26		72	32–48 at 3.2 slow progress thereafter
Sphenoparietal	29	slow at once	65	29–46 at 30. slow progress thereafter
Sphenotemporal 2	30		67 at 3.9	gradual progress
Sphenotemporal 1	31		64 at 2.4	31–62 at 0.5 burst of activity at 63
Masto-occipital 1 and 2	30		81	32–45 at 1.25 activity between 46 and 64 final burst of activity
Parietomastoid	37		81	almost inactive till 50 slow progress thereafter
Squamous posterior	37	almost inactive till 62	81	burst of activity at 63 burst of activity at 79
Squamous anterior	37		81 at 3.2	burst of activity at 63 burst of activity at 79

The sagittal and spheno-frontal sutures commence to unite at twenty-two years. There is slow progress until twenty-six when the period of rapid union sets in and lasts till about thirty years. By this time the sagittal is almost completely united and its terminal inhibition is of no real consequence. The spheno-frontal however is only three-quarters united at this age and falling under the restraining influence, its union remains practically stationary until the final burst of activity in the early sixties.

The upper part of the coronal suture, starting to unite two years later than the sagittal, follows a similar course but its terminal inhibition is not nearly so prolonged as that of the spheno-frontal for it is remote from the zone of maximum emancipation (squamous).

The pteric part of the coronal, the entire lambdoid and the third part of the masto-occipital all commence to unite at twenty-six and progress as far as thirty years is rapid. The pterica and asterica have united only about one-half their extent by thirty but the upper lambdoid and the third masto-occipital, being further removed from the zone of maximum emancipation, are three-quarters united. At thirty years retardation sets in and complete union attained at ages varying from forty-one to seventy-two.

APPLICABILITY TO INDIVIDUAL CASES

In a study of this kind it is natural for the reader to inquire what value it has for the identification of age in individual cases. Indeed when we first commenced the work we had in mind the utilization of suture closure, along with other features of skeletal differentiation, in estimation of the actual age of the person. In order to show what may be attained by the method I have taken thirty skulls at random and worked out the suture age for comparison with the known age. The results of this investigation are given in Table III. While the average computed age very closely approximates the average real age, as might be expected, the results in individual cases leave much to be desired for the average deviation is rather more than six years. I have not claimed greater accuracy than this for age estimation based upon any single segment of the skeleton and when one considers the individual variability in suture closure progress this result is far from discouraging. But it cannot be denied that so far our work does not justify the uncontrolled use of suture closure in estimation of age. Frédéric (7) concluded that it is not possible to gauge the age of any particular individual closer than within one decade and after all we have not greatly bettered this result.

Our results are of distinct value however when taken in conjunction with indications given by other parts of the skeleton.

The real value of this work lies in the light thrown by it upon the nature of suture closure. I have already dwelt upon this aspect of our results and it is only after presentation of our complete investigations, which comprise Negro Stock and comparative mammalian anatomy, that we shall be able to demonstrate satisfactorily the full truth concerning suture closure. At the moment I can merely reiterate my belief, expressed in several places above, that there is a mammalian type of order and progress in suture closure from which various degrees of emancipation are exhibited in higher Primates. In Man the greatest degree of emancipation is attained. It is too early as yet to speculate upon the very interesting question whether the amount of individual variation should be construed as an indication of inadequacy in this emancipation, or whether the type of skull may have some real relation to the precise individual character of suture closure progress. Work along this line has been in prosecution for many months but so far I am not ready to report.

TABLE III. ESTIMATION OF AGE BY ENDOCRANIAL CLOSURE

Skull	Suture age circa.	Actual age	Dev.	Skull	Suture age circa.	Actual age	Dev.
94	25	28	—3	618	30	30	
156	40	45	—5	649	27	22	+5
185	40	40		654	65	42	+23
267	25	25		671	35	33	+2
301	35	34	+1	678	40	38	+2
328	55	38	+17	708	45	32	+13
354	65	48	+17	711	43	47	—4
396	41	60	—19	772	37	40	—3
429	35	40	—5	786	43	45	—2
431	45	40	+5	794	33	32	+1
445	30	36	—6	799	35	36	—1
499	43	55	—12	823	30	33	—3
504	35	37	—2	828	58	68	—10
507	35	49	—14	876	43	ca 40	+3
617	37	32	+5	896	55	53	+2

Average of thirty. Suture age 40.2 years. Actual age 39.9 years. Dev. 6.2

SUMMARY

The numbers of paragraphs in this summary refer to the numbers of corresponding subject headings in the table of contents.

1. So little work has hitherto been done upon endocranial suture

closure in material of definitely known age that it is necessary to make an absolutely fresh start. The previous work of Parsons and Box is the most helpful and suggestive.

2. The present survey included 307 male White skulls of age known either precisely or within a year or two. But since the making of the survey in 1921–22 we have had opportunity to test its principles upon a considerably increased collection and we find the principles are confirmed.

3. By a detailed preliminary survey we were able to identify a definite trend of progress in suture closure. There is obviously considerable individual variation but the mean values of the trend are closely similar in series restricted to one Sex and Stock. Abmodal examples must naturally be eliminated.

4. A three-yearly moving average or trend illustrates in a practical visual manner the progress of suture closure and its relation to age. It is unnecessary and indeed it would seem unwise, at least at the present stage, to smooth the graphs too much.

5. Endocranial closure progress compels us to adopt a new method of grouping the sutures. The group of vault sutures includes sagittal (and metopic), coronal and lambdoid with some reservations on the partes pterica and asterica of the two last. It does not include the squamous suture. A second group presenting an entirely different age-relationship in closure progress has been named by us the circum-meatal group. This includes the spheno-temporal, squamous, parieto-mastoid and occipito-mastoid sutures. The third and last group, styled the accessory group, comprises spheno-frontal and spheno-parietal sutures.

6. Frequently in the sagittal and lambdoid, rarely in other locations also, there occurs an apparent failure of union with heaped up bone tissue along the margins of the unclosed part. We have described it under the heading of lapsed union. This must be clearly distinguished from union which, though in fact incomplete, would normally have been completed later.

7. The elimination of specimens exhibiting what is known or suspected to be abmodal progress is an important step.

8. The sagittal suture commences to unite at twenty-two years and is practically completely closed at thirty-one, progress becoming much more rapid at twenty-six.

9. The coronal suture begins to close at twenty-four years. From twenty-six to twenty-nine there is rapid progress and thereafter union

spreads very slowly, completion being attained at thirty-eight. The pteric part is delayed in its commencement until twenty-six and in its completion until forty-one but it shows the same speeding up from twenty-six to twenty-nine.

10. The lambdoid suture begins to close at twenty-six and though progress is rapid until twenty-nine it is fitful thereafter until complete at forty-two. The asteric part, though commencing at the same age does not complete its union until forty-seven.

11. Crania presenting abmodality in suture closure are not infrequent. Sometimes the irregularity is localized to a single suture, or even to the segment of a suture. All such crania in this series have been rejected. The main cause of rejection is delayed union and this delay is more frequently met with in the lambdoid suture than in the sagittal or coronal.

12. Endocranial closure of vault sutures in male White crania commences and terminates in the order, sagittal, coronal, lambdoid. The discrepancy in age is greater for completion of union than for commencement. The age period of twenty-six to thirty years is the special period of suture closure. At whatever stage union may have progressed there is a significant slowing up once this period is passed.

13. The circum-meatal group of sutures presents a closure pattern quite different from that of the vault sutures. This group comprises the spheno-temporal, squamous, parieto-mastoid and masto-occipital suture.

14. The masto-occipital suture commences to close just about the thirty-year period when lethargy in progress is setting in. A second period of activity is shown in the fifties and a third and final burst about eighty years. The inferior part however commences at twenty-six, slows down at thirty, gathers speed again in the fifties and finally reaches complete union in the seventies.

15. The inferior part of the spheno-temporal suture shows a closure pattern similar to that of the major part of the masto-occipital but complete union is rare. The superior part is even more restrained in its degree of closure.

16. In the squamous suture closure does not begin until the late thirties and is rarely over complete, at least in the anterior part.

17. Closure in the parieto-mastoid suture presents a pattern similar to that of the squamous suture but complete union is attained as in the posterior squamous, at eighty or over.

18. The circum-meatal group clearly shows various degrees of emancipation from the closure pattern typified by the vault sutures. The

greatest degree of emancipation occurs in the anterior squamous suture.

19. The retarding influence which makes its appearance in suture closure at thirty years affects some sutures more than others but certain crania seem to exhibit retardation in more marked degree than others. In these sequence of union may remain unaffected.

20. The spheno-parietal and spheno-frontal sutures form a link, as it were, between the vault group and the circum-meatal group. We style them the accessory sutures.

21. In the spheno-parietal suture closure, commencing at twenty-nine years, is almost immediately retarded but shows a second burst of activity in the fifties carrying union to completion in the early sixties.

22. Union in the spheno-frontal suture begins at twenty-two, shows the usual activity from twenty-six to thirty years, after which oscillation and slow progress supervene until complete closure at about sixty-five.

23. Suture closure exhibits a definite periodicity, the most extreme activity occurring between twenty-six and thirty years. Subsidiary periods of activity occur in the fifties and the late seventies.

24. The individual variability in progress of suture union makes it unwise to depend too much upon the stage as an age marker, valuable as the indications may be when linked up with other features. The average progress of a large number of crania however shows that there is a definite pattern in suture union. The most primitive form is still represented in the sagittal suture and the greatest degree of emancipation from that primitive form is exhibited in the squamous suture.

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LITERATURE

ANTHROPOLOGY IN GENERAL

WORKS OF MORE GENERAL NATURE

THE UNITY OF ANTHROPOLOGY. By Rivers (W. H. R.)—*Presidential Address*, Roy. Anthrop. Institute, *J. R. Anthrop. Inst.*, 1922, LII, 12–25.

The author, whose untimely death (June 4, 1922) is universally regretted, emphasizes "the unity which underlies the apparent diversity of the studies which come within the scope of the activities of our Institute." He has this to say as to physical anthropology (p. 23): "I believe there is no branch of our science in connection with which the failure to recognize its unity has had more blighting effect than is the case with physical anthropology; no branch where recognition of this unity has a greater promise of advance. At the same time there is no part of the science the material of which can be so easily collected. The collection of somatological data is not open to the many sources of misunderstanding by which even in the most expert hands the study of social behaviour, of language and of the psychological aspects of anthropology are beset. To one with an anatomical training of an ordinary kind there lies an easily accessible field, the neglect of which I believe to be a result of undue specialism, a result of the failure to appreciate a unity of anthropological studies which, if grasped, must make apparent the abundant opportunity with which the physical anthropologist is now presented."

ANTHROPOLOGIE. By G. Schwalbe & E. Fischer, with the collaboration of R. F. Graebner, M. Hoernes, Th. Mollison and A. Ploetz. 8°, Leipz. & Berl., 1923, 684 pp. (B. G. Teubner, $9.20).

The book is one of a series on the "Kultur der Gegenwart." Its realization is largely due to Gustav Schwalbe, whose death in April, 1916, was the greatest of the many losses German anthropology has sustained in late years; and it contains Professor Schwalbe's last work on the "Derivation of Man, and His Oldest Forms." It is not a duplication but rather a complement to Martin's "Anthropologie" though it includes, unnecessarily it would seem, a section on the methods of measuring.

The contents are, an altogether too short chapter on "The Concept, Definition and History of Anthropology" by Eugen Fischer (1–11); a section, also somewhat inadequate, on "The Techinque and Methods of Physical Anthropology" by Theodor Mollison (12–36); "General Anthropology," by E. Fischer and Th. Mollison (37–122); "Special Anthropology: Races," by E. Fischer (122–222); and "The Derivation of Man and His Oldest Forms," by Gustav Schwalbe (223–338). The second half of the volume is devoted to Archeology, Ethnology and Social Anthropology, contributions which, it would seem, might have been more advantageously published separately.

The section foremost in value is that by Schwalbe on Early Man and his derivation. We learn that this part was corrected by Professor Schwalbe shortly before his decease, so that aside of other it will always possess a historic value as the final opinions on the subject at that date by the then foremost European scholar of the question.

The other sections are somewhat more encyclopaedic and not quite on a par with that on "Man's Derivation." They contain much of value, yet on the whole do not reach the topmost level now possible or possible to their authors who stand in the front rank of German anthropologists. The chapters on America, in particular, are not everywhere as precise or up to date as they might have been, which however, in non-American writings has long been the rule rather than the exception, and is doubtless due to the great difficulties scholars abroad are under in respect to American anthropological progress and literature. Some day, when conditions have once more become normal and minds may once more be fully given to science, the same authors will doubtless give us something more nearly perfect.

Anthropologie. By Frizzi (E.)—Sammlung Göschen. Leipzig, 1921, 133 pp.

A compendium of physical anthropology in pocket edition. Nothing new is given in this almost too condensed work, which deals chiefly with the somatometric and craniometric technique.

A. H. Schultz

Medical Anthropology. By Preble (Edward)—Repr. fr. *Med. Record*, April, 1922, 12mo., 29 pp. (Wm. Wood & Co. N. Y.).

This very interesting and exceptionately accurate little volume is merely an illustration of what may, and it is hoped will, be done in this line on a larger scale. The author points out the well known fact that Vierordt's "Anatomical, Physiological and Physical Tables and Data" are antiquated, and that there is need of a special modern work giving in a succinct and readily useable form the many facts that are now known or regarded as well established, such a volume to be known as "Medical Anthropology." The present paper is merely a line of indications of what would be included in such a volume. Dr. Preble has long been collecting data for a work of this kind, and it is hoped that he may before long realize its completion.

The Outline of Science. Edited by J. Arthur Thompson, Regius Professor of Natural History in the University of Aberdeen. 4 vols, large 8°, with over 800 ill's. N. Y. & Lond., (G. P. Putnam's Sons), 1922.

These four volumes are given as "a plain story simply told" and at the head of the cover of each volume we read the almost challenge: "So accurate that the expert cannot cavil at it."

The expressed intention of the Editor was to produce a set of high-class popular books on branches of science which are of more general interest; and in possibly most respects this aim has evidently been achieved.

The subjects dealt with range from chemistry, some of the applied sciences and astronomy, to all branches of natural history, culminating with "psychic science;" but they are not always given in a logical order. The sections of more direct interest to anthropology are: *Vol. I*—The story of evolution; Adaptations to environment; The struggle for existence; The ascent of man; Evolution going on; and The dawn of mind; *Vol. II*—The body machine and its work; How Darwinism stands to-day; The science of mind; *Vol. III*—Psychic science; and *Vol. IV*—Ethnology.

Available space makes it impracticable to review all these articles; it must suffice to say that most of them leave little to be desired unless it be, perhaps, a greater wealth of details; but some serious objections are due to the articles on "The Ascent of Man" and on "Ethnology."

In the section on Man's Ascent there are a whole series of points that do not exactly conform to the above given claim for accuracy. On p. 165, we read "The probability is that the cradle of the human race was in Asia;" while the fact is that, outside of some loose statements, we have no foundation for such an assumption. On p. 166 is the statement that "The over-crowding of the teeth that followed the shortening of the snout was one of the taxes on progress [in evolution] of which modern man is often reminded in his dental troubles." As a matter of fact the crowding of teeth is only observed in modern man. On p. 168 the statement is made that the remains of the Pithecanthropus "were found by Dubois in 1894" while, as is well known, the true dates were 1891 and 1892. On p. 169 we are told that the Mauer Jaw was discovered by Dr. Schoetensack, which is incorrect, as are some of the immediately following statements. On p. 170, last paragraph, the unwarranted (though not original) assumption is given that "the modern type [of man] was distinguishable from its collaterals hundreds of thousands of years ago." On p. 171, the Magdalenian and Crô-Magnon "Cave men" are referred to "between the Third and Fourth Ice Ages." On p. 172, we meet once more with the fallacy of "The probability is that after their [the Cave men] decline, Europe was re-peopled by immigrants from Asia." On p. 173, we read that "evidences of Neolithic man occur in situations which demand a much greater antiquity—perhaps 30,000 years." On p. 175 is found the statement that "When the original peculiarities, say, of Negro and Mongol, Australian and Caucasian, arose as brusque variations or 'mutations,' then they would have great staying power from generation to generation"—which is too much of an assumption. On p. 176, in enumerating the various races of man, the American Indian is forgotten. Some of the impressionistic illustrations hardly fit a serious article, and there could be made other objections. The bibliography of this section is too poor and inadequate to be of much use.

The article on Ethnology, as that on Man's Ascent, should have been given to an expert on the subject, and England has such experts. The very name is ill chosen, for the term "Ethnology" has a different meaning in different countries and is not the equivalent of "Anthropology" which this article really deals with. The space given to this great subject—twelve printed pages—is wholly inadequate. Its illustrations are a flashy head of a "Red" Indian with seven small portraits of individual men of other races. The term "Red" Indian is used again in the otherwise very sensible classification of races, as though all the efforts of American Anthropology to show that the Indian was a brown man, were unknown. The still wholly problematic endocrine theory of racial causation is given perhaps more prominence than it as yet deserves. On p. 1099 we are astonished to meet once more the old fallacy that "the American Indians were preceded by the 'Mound Builders.'"

There is no fault to find with the bulk of the text as far as it goes, but the field it covers is too restricted. Anthropology is probably, of all sciences, the richest in matters of wide popular interest, the bulk of which is not even touched upon. Finally, the bibliography is not as representative as it might be, and in some respects is decidedly inadequate.

Man and Culture. By Wissler (Clark).—12mo., N. Y., 1923, IX-371 pp. (Thos. Y. Crowell Co., $2.75).

A very readable little book, bearing throughout the distinctive stamp of the author. It deals essentially with culture, but in a number of instances approaches subjects of interest to Physical Anthropology. This is particularly the case in two of the terminal chapters, that on "Race and Culture" and that on "Domestication of Man and its Consequences." Dr. Wissler properly does not believe in race equality and attaches considerable weight both biologically and culturally to man's self-domestication. But on pp. 353–4, there seems to have been a lapse in his general caution and we read, relative to man's origin "Zoologists tell us that we live in the age of mammals, a zoological era that began in eocene time and still flourishes. The chief characteristic of this period has been the appearance and distribution of mammals. We are also told that mammals as a whole seem to have been distributed from an Old World center, the precise location of which may be safely defined as Asiatic. Readers familiar with such zoological literature will recall the distribution maps that have been published showing how the different species of mammals swarmed out of the Asiatic continent and found their way to the outermost parts of the earth. Among these mammals was man. So far as we know, he was the last, or most recent, of these swarms." It is only just, however, to say that the generalization which, so far as man is concerned, has not the slightest foundation of facts, is not Dr. Wissler's. There is also in the final chapters an unnecessary infusion, it seems, into a scientific treaty on culture, of the already much overdone "Nordic" question.

GRUNDZÜGE DER PALÄONTOLOGIE. II—VERTEBRATA. By v. Zittel (Karl A.)—4th ed., 8°, München-Berlin, 1923.

Pages 653–662 of this otherwise deserving work are devoted to *Hominidae.* Regrettably, this section is very unsatisfactory. It is much behind time; there are errors; and there are statements with which anthropology cannot agree.

Pithecanthropus is "fairly probably only an old species of genus *Homo.*" Its remains comprise *one* tooth. As the skull has no crests "there can therefore be no doubt that the canines could not have been larger than the incisors"—an unaccountable assertion in view of the evidence of the platyrrhine apes, the gibbons, some chimpanzees and the females of other anthropoid apes. "Also the form presented by the M_3 can at most occur in man, but never in an anthropoid ape"—notwithstanding the fact that the tooth is, in the essentials of its crown, more like that of an orang than that of any human being. In connection with Early Man there is an illustration of his stone implements which is out of place in a book on zoölogy. As to North and South America, we still read of the Calaveras skull with what Wilson and Sinclair said about it, and of Ameghino's "find," all of which is ancient and pretty well discredited history. And there is much other poverty. Why cannot our friends from collateral sciences, so long as they feel it incumbent upon them to write about anthropology, instead of riding it as an easy hobby, do justice to anthropology?

THE GEOLOGICAL LAWS OF THE POPULATION WITH SPECIAL REGARD TO THE CZECHOSLOVAK REPUBLIC. By Matoušek (Otakar)—8°, Prague, 1922, 12 pp.

As a result of his interesting studies on the Geology and Population of Czechoslovakia the author comes to the conclusion that "The same geological formation has regularly as a direct and indirect consequence (with certain types of deviations) the formation, from a demographic and other points of view, of one type of population." It is regrettable that the English in which the study is written, contains so many imperfections.

L'HÉRÉDITÉ MENDÉLIENNE ET L'ANALYSE ETHNOLOGIQUE. By Mendez-Corrêa. *Natur & Mensch*, Berne, July, 1922; Repr. 7 pp.

The author points out the difficulty of deriving definite conclusions from works of anthropological analysis, on account of the backward state of the methods, the provisional character of anthropological classifications, and the possibility of attributing the same morphological facts either to crossing, mesological influence, race, or domestication. More particularly he shows how the problem of such analysis changes its aspect according to one's own subjective conceptions as to the part of heredity in the crossings. Mendelian heredity in man presents contradictory facts. Admitting this, anthropological media lose their interest and the problem of analysis exacts the aid of history, so that we may know the dates of the penetrations of alien blood in a certain population.

M. C.

Os Problemas da Analyse Etnologica. *Rev. Faculd. Let. Porto,* no 5–6, 1922, Repr. 18 pp.

A development of the subject dealt with in the preceding article. Author discusses the anthropological classifications of Blumenbach, Quatrefages, Deniker, Sergi. etc., concluding that a natural classification of races must be based on the principles of subordination and association of characters. He thinks it necessary to select and reduce in number the anthropological methods, as there is in them much that is useless. He next deals with the difficulty of recognizing what is an individual variation, a pure race, a crossing, or a simple geographical variety. Lastly he analyses the relations between the question of heredity and his problem.

M. C.

Man and the Cosmos. An Introduction to Metaphysics. By Leighton (Joseph Alexander), 8°, N. Y. and Lond., 1922, 578 pp. (D. Appleton & Co., $4.50).

The author, Professor of Philosophy in the Ohio State University, has given us a book "the core of which is its concentration on the problems of the individual man—how and why he exists, what is his place in the scheme of the universe, what is his destiny, and how can he improve his own place in the Universal Order, and contribute to raising the destiny of the whole human race"—all of which is really close to general and especially social Eugenics and not very metaphysical, a term which may unjustly prejudice some against the volume. The book is in the main philosophical, and there is more of scholastic philosophy with sociology than of natural philosophy. The main subdivisions are: Metaphysics; the Theory of Knowledge; the General Structure of Reality; Empirical Existents, under which are Physical Reality; Life and Mechanism, Evolution, its Factors and Doctrine, Evolution and Teleology; Personality and its Values; and Cosmology.

There is much good thought embodied in the book—pity it could not have been presented in a more generally approachable form, which, as well shown in the "Postcript" would have been feasible; for it deserves a wide reading. Also, there is a tinge of pessimism in some of the author's conclusions which, had matters been viewed more strictly biologically might have been reduced to mere criticism. But this does not materially detract from the substantial value of the book.

To physical anthropology the work is of interest in as far as it approaches Eugenics, though it is social rather than anthropological Eugenics.

The Pofulation Problem. A Study in Human Evolution. By Carr-Saunders (A. M.) 8°, Oxford, 1922, 516 pp. (Oxford University Press, American Branch, $7.00).

"Many different questions connected with population are frequently discussed at the present day. This book is designed not so much as a contribution to the study of any one of these questions in particular as an attempt to trace back to their origin the main problems which now attract attention and to indicate their relation one to the other—to view the whole problem in fact from an historical and evolutionary standpoint."

After giving the historical view of the question of population the author deals with the quantitative aspect of the problem; with the qualitative aspect; human fecundity; human history; the influence of environment on man; heredity in man; evolution of physical and mental characters. "An attempt has been made to trace the origin of problems of population from their source and to indicate their nature and interdependence. They have been traced back to man's place in nature. The ancestors of man must at one time have been subject to the same conditions as those to which all species in a state of nature are subject. These conditions were investigated, and it was shown that fecundity is in the main determined by the sum of all the dangers to which the young of any species are exposed—allowance being made for the fact that a certain proportion of ova will not be fertilized. It was also shown that change or history—if history can be spoken of in this connection—is due to germinal change alone, and it was further indicated how it may be supposed that germinal change comes about. The early stages in the moving away of the pre-human ancestor from these conditions elude our inquiry, though certain deductions may be made as to the main outline of what happened. For evidence as to the latter stages, until we reach historical times, we are chiefly dependent upon the method of using our knowledge of existing primitive races as throwing light upon prehistoric races.

Problems of population fall under two main headings, problems of quantity and problems of quality. . .Those who base upon germinal change their hopes for the physical condition of the human race in the future are building upon sound foundations. However much our power to control and regulate vital processes may increase—and it is clearly upon the verge of a very great increase—in the end a satisfactory physical condition can only be the product of a certain germinal constitution. On the other hand those who think that germinal change in mental characters will effect the evolution of society and mould the course of history are upon the whole mistaken. The course of history is in the main dependent upon changes in tradition which are for the most part independent of germinal change. .But as far as tradition is equalized, so far do innate mental differences manifest themselves as between man and man, and since tradition is more or less equalized, if not within races, at least within classes in the same race, to that degree is mental endowment of pre-eminent importance to the individual."

The book is a well documented, serious production and well worth perusal.

MANKIND AT THE CROSSROADS. By East (Edward M).—New York, 1923, 360 pp. (Charles Scribner's Sons, $3.50).

A serious book by a serious and able author and thinker. It deals with the great human themes which since Malthusius and Galton are increasingly troubling students of man's future, namely human overproduction in relation to nature's capacities of food supply and the breeding of inferiors. The author believes that "it can be stated categorically that unless voluntary parenthood is taught to all classes of people by the governments of the various white nations as a serious, momentous public health measure, there will be no substantial change in the population growth of these countries until the comparatively sudden change of some 50 years hence necessitated by temperate-zone saturation. The white race holds a considerable quantity of fairly rich land which is not now very densely peopled, and the inertia of the present day velocity will carry it to the danger-line and probably beyond it. With agricultural efficiency mounting very slowly, with the small reserve of new land diminishing appreciably each year, with almost no effort being made to conserve soil fertility, with the small potential store of excess food vanishing like a candle burning at both ends because of the great population increase of the industrial countries on the one hand and of the newer agricultural countries on the other there is likely to be a debacle which will turn the world more topsy turvy than the troubles of the last few years. If population growth were slow there would be time for adjustment. With things as they are difficulties are likely to loom suddenly as ships in a fog. Of course. . .there will be no sudden starvation succeeding a time of feasting. Nevertheless. . .a sudden drop of 25 per cent in the grain crop, just such a drop as has occurred time and again before, when there are 3,000 million people in the world will make what is left of them awaken to the folly of negligence. . .This is the world question; it is a question of reducing a swiftly increasing population to fit a rapidly diminishing food reserve. . .If the human race really desires a continued progress, a fair chance and a longer and happier life for every individual the birth rate must come down throughout the whole population and not merely within the one section which furnishes those of greatest social worth."

THE EVOLUTION OF CLIMATE. By Brooks (C. E. P.)—small 8°, Lond., 1922, 173 pp., (Benn Brothers, Ltd., 8/6).

A book on a subject of very great importance to Anthropology; for if we knew the changes in climate in the northern hemisphere since the Miocene or at least the Pliocene, and particularly during the Quaternary, our studies on Early Man and his spread would be very much lightened. The book, in fact, is devoted principally to the Ice Age.

The work is more a high-class review of the subject than a contribution based on original studies. For the Ice Age in Europe, the authors adhere to the Penck-Brückner classification. The time relations between the European and North American glaciations "are not yet fully worked out, but there seems little doubt that they were contemporaneous in the two continents. The correlation is not perfect, however, since the United States geologists recognized altogether five glaciations." (p. 48).

The references to man are rather weak as could hardly be otherwise in the absence of an extensive research in this field. Nevertheless the book is welcome to students of Early Man, for it presents the subject of climatic changes during the Glacial period in a concrete and digestible form; and it adds some notes on Asia.

In Search of a Soul and the Mechanism of Thought, Emotion and Conduct. By Hollander (Bernard), Lond., Kegan Paul, Trench, Trubner & Co., (N. Y., E. P. Dutton & Co.), imp. 8°, 2 vols., 516 &361 pp., no illustr's.

A remarkable, large work, evidently the life work of the author. Large in scope, remarkable for the array of literature and subjects dealt with, which considerably exceed the promise of the title. The field it actually covers will be seen from the titles of the sections: The History of Philosophy and Science from Ancient Times to the End of the XVIII Century; Views of the Soul, Mind and Brain in the Middle Ages; Views of the Soul, Mind and Brain in the XVII and XVIII Centuries; The History of Philosophy and Science in the XIX Century; The Reception of Gall's Doctrine; History of Modern Brain Research; History of Modern Philosophy and the Progress of Science; Analysis of Man's Psychical Nature; The Mental Functions of the Brain; Genius Insanity and Crime; and Unexplored Powers of the Mind.

The two large volumes are a mine of gathered philosophical, scientific and medical opinion, much of which is of interest to physical anthropology. Yet the information is not always complete nor always entirely accurate, and the author is not always free from bias. A striking example of the latter, rather unexpected at this day and in a physician of such a standing as the author, is a leaning towards phrenology and a correspondent dislike of modern craniology; though his objections to the latter are not without some justification.

If the otherwise very deserving work reaches a future edition it would be of great advantage if it were divided into a number of smaller volumes each dealing with a special phase of the field covered.

Grundriss der menschlichen Erblichkeitslehre und Rassenhygiene. By Baur (E.), Fischer (E.), and Lenz (F.)—2 vols., München, 1921, 251 pp.

This work by three experts represents a summary of our present knowledge of heredity in man. Of special interest to the anthropologist is the second part by Fischer on human racial differences. These are treated not merely morphologically but from the point of view of their dependence on inheritance and environment. It is shown that the first of these two factors plays much the more important role in determining, for instance, the head formation, as best illustrated by some hybrid races. The problem of hereditary influence on the pigmentation of skin, hair, and eye is discussed at length. The individual arrangement of the patterns on palms and soles are without doubt the result of heredity, but conditions here are very complicated. Outer factors figure considerably in stature and body-weight. A further chapter is devoted to racial origin and racial biology. It deals briefly with the evolution of man, with the process of racial differentiation, and with the relations between races and nations. This is followed by a description of recent races, especially European, based upon factors known to be hereditary.

A. H. Schultz.

Body Build and its Inheritance. By Davenport (C. B.). Publication No. 329 of Carnegie Institution of Washington. 1923 (179 pp. 53 tables, 53 textfigures and 9 plates).

This work is divided into 3 parts. Part I considers the definition and ontogeny of build. From, in part, new data are drawn curves of relative chest girth from birth to 14 months (by months) and from birth to 25 years (by years). Changes in build in later life are considered. In Part II the results of mass studies in heredity of adult build are set forth. It is concluded that where relative chest girths are not available weight÷stature squared affords the best index of adult build. Five classes of build are adopted, named very slender, slender, medium, fleshy and very fleshy, defined by index of adult build as follows: (with English equivalents in parentheses)V. S., 1.40–1.80 (20–25.4); S, 1.81–2.14 (25.5–30.4); M, 2.15–2.56 (30.5–36.4); F, 2.57–3.05 (36.5–43.5); V. F., 30.5–4.5 + (43.5–64 +). The relations of variations of build to nutrition, endocrine disorders and disease are considered. A clear correlation between mid-parental build and that of offspring is revealed and the greater regression to mediocrity of progeny of stout parents than of slender parents is shown and the conclusion is drawn from this fact that fleshy build results from one or more dominant factors, while slenderness is chiefly recessive. A tendency toward the mating of persons of similar build is revealed.

In the third part family studies in build are made. When both parents are slender nearly all children are slender or nearly so (2.6 per cent fleshy). When both parents are fleshy 67 per cent of progeny are fleshy or very fleshy. When heterozygous parents are mated the progeny show increased variability. The back cross of heterozygous to slender shows a segregation into slender and fleshy. Apparently there are genetically different forms of build, even with the same index. Thus there is a slender biotype, allelomorphic to fleshy, dependent on one factor. There is apparently a fleshy build dependent upon 2 and also one dependent upon 3 gametic factors (not sex-linked). These different types are scattered through the mixed population of the United States; they show themselves in the varous statistical analyses of families. Indeed, the general polygon of frequency of the various indices of build based on over 1,000 persons shows 3 modes and 4 are obvious in other cases. These modes appear at all ages from birth to maturity. They are the mode of the slender biotype, of a medium biotype (which is hard to distinguish phenotypically from a class of heterozygotes), of a fleshy biotype and of a very fleshy biotype. In the 25 year old males these biotypes have a relative chest girth of 44. 47, 49 and 52 per cent respectively. The clear evidence of genetical factors in build (endocrinal and others) is opposed to the conclusion of those physiologists of nutrition who ascribe differences in build purely to difference in the relation of intake and expenditure of food energy.

C. B. D.

TRANSACTIONS II INTERNATIONAL CONGRESS OF EUGENICS (2 volumes)—8°, Baltimore, 1923 (Williams & Wilkins Company. $6 per vol., $11 for both).

The two handsome volumes, of approximately 800 pp., with numerous illustrations, constitute the Transactions of the II International Congress of Eugenics, which was held in New York in September, 1921. The first volume is devoted to Eugenics, Genetics and the Family; the second to Eugenics in Race and State. There are in all 108 papers, and some additional articles presented before the Congress have been published outside of these Proceedings.

The articles are of varying value, the one of most general interest being doubtless that by Leonard Darwin on the "Importance and Methods of Eugenical Societies."

To review the various articles, or even briefly to indicate their contents, would require many pages. It must suffice in this place to name those papers which are of special interest to Physical Anthropology. They are (outside of the articles of a general nature) as follows: *Vol.* I—No. 16: The Frequency of Mutation and the Incidence of Hereditary Traits in Man. By Dr. C. H. Danforth; No. 23: Comparison of the Incidence of the Supracondyloid Process in Groups with Normal and Abnormal Mentality. By Dr. R. J. Terry and Lee D. Cady; No. 29: Main Results of a Statistical Investigation of "Finger Prints" from 24–518 Individuals. By Kristine Bonnevie; No. 33: Individual and Racial Inheritance of Musical Traits. By Dr. Carl E. Seashore; No. 35: The Consequences of War and the Birth Rate in France. By Dr. M. Lucien. *Vol.* II—No. 1: La race chez les populations mélangées. By Dr. G. V. de Lapouge; No 2: Notes on the Body Form of Man. By Dr. R. Bennett Bean; No. 3: The Scientific Prediction of the Physical Growth of Children. By Dr. Bird T. Baldwin; No. 4: The Height-Weight Index of Build amongst the Italian Adolescents of 50 Years Ago. By Dr. V. Giuffrida-Ruggeri; No. 5: Height-Weight Index of Build or Robustness. By Fabio Frassetto: No. 6: Other Forms of the Law Governing the Relation between Stature and Weight in Adults. By Fabio Frassetto; No. 7: Harmonic and Disharmonic Race Crossings.

By Dr. Jon Alfred Mjoen; No. 9: Observations and Queries as to the Effect of Race Mixture on Certain Physical Characteristics. By Dr. E. A. Hooton; No. 11: The Mortality of Foreign Race Stocks. By Dr. Louis I. Dublin; No. 12: Race Amalgamation in Hawaii. By Dr. Frederick L. Hoffman; No. 13: Some Results of Race Mixture in Hawaii. By Dr. L. C. Dunn; No. 14: Inter-marriage between Jews and Christians. By Dr. Maurice Fishberg; No. 16: Eugenic Problems of the Slavic Race. By Dr. Paul R. Radosavljevich; No. 17: Distribution and Increase of Negroes in the United States. By Prof. W. F. Willcox; No. 18: The Problem of Negro-White Intermixture and Intermarriage. By Dr. Frederick L. Hoffman; and No. 21: Some Eugenic Aspects of the Problem of Population. By Dr. Raymond Pearl. But even in the remaining articles, all of which cannot be mentioned, there is much of value for the anthropologist.

The illustrations include a series of plates of the exhibits.

GROWTH AND VARIATION

Human Types and Growth Reactions. By Stockard (Charles R.)—*Am. J. Anat.*, 1923, XXXI, No. 3, 261–288.

"The two groups into which almost all ordinary persons fall more or less exactly may. . .be termed the *Linear Type* and the *Lateral Type*. The linear type is the faster growing high metabolizing thin but not necessarily tall group, while the lateral type is slower in maturing and is stocky and rounder in form. . .The two types are more clearly expressed in men than in women since the growth and glandular reactions are more decided in the male than in the female and are also freer from physiological disturbances." These types are modifiable by environment. They "occur among all races and nations of men, but some races or groups show a great majority of one type, and only a few of the other. So that, in general, it may be said that one race is of the linear type and another of the lateral, whereas the actual ancestry or stock of the races may have been closely similar. The upper classes of people in England and Germany illustrate the point. Almost all the Englishmen of this cast are linear in type, thin and dolichocephalic, while almost all of the Germans are of the lateral type, stocky and brachycephalic. Yet some of these Englishmen are decidedly lateral and some of the Germans are decidedly linear in type. All in all, however, the English may be called a linear type race and the Germans a lateral type race. . .In diagnosing these types it is very essential to take into consideration the age factor. The well expressed typical condition may only be depended upon during the twenties, at times younger than this the type may not be fully expressed and at period above thirty it is becoming modified by age changes. . .Again there are persons who do not properly fall into either type, nor are they typical intermediates, or blends of the two types. . . In spite of this there is much evidence to indicate that environment may modify the growth regulating mechanism and so tend to change the brachycephalic into the dolichocephalic head."

Criteria of Normality in the Growth of Children. By Robertson (T. Brailsford)—*Med. J. Australia*, May 27, 1922 (repr. 19 pp.)

"Individual deviations from the average standard weight or stature, when they are not too extreme, have very little significance except when viewed with reference to the whole growth curve of the individual under consideration. The bodily dimensions of perfectly normal children vary even more than those of adults, and, provided a child is developing along a steady growth curve which is parallel with the normal standard of its sex, race and environment, there is no adequate reason for supposing that it is abnormal simply because it departs rather widely from the arbitrary standard of the average. What is actually required, therefore, in order to estimate the normality of the development of a child, is a means of determining the degree of parallelism of its development with the standard, and the degree of probability that a given departure from the standard is normal. These may be ascertained by plotting the chosen dimension (i. e. weight or stature) of the child upon a chart on which are drawn a series of parallel growth curves differing from the standard by successive intervals corresponding to the variability of the dimension."

Sex and Growth Features in Racial Analysis. By Fleming (Miss R. M.).—*Man*, May, 1922, No. 46, 69–75.

Women and children have been measured to investigate relations of sex and growth to racial characters, and over 400 children are remeasured at intervals to get data. Rural and Urban cases have been selected for running comparisons, and care is taken not to mix the results for widely different types (e. g. marked blonds and brunettes, marked long heads and broad heads). The differences of growth as between boys and girls are closely followed on the same individuals and hints of influence of race type on developmental stages are already apparent. A general tendency towards greater increase of head breadth than of head length is clearly evident; this is specially marked among girls in their earlier years, and it seems that a girl of 8½ is comparable with a boy of 10 as Pryor has already claimed on other grounds. Girls change more slowly after the ninth year, and practically not at all after 16, boys usually change markedly after 10. The continuous frontal boss of infancy weakens earlier in girls than in boys. As Fleure and Parsons have both shown British women have shorter heads and darker colouring than men as a general rule. Comparisons with Pittard's work on the Valais, Fürst and Hansen's on Greenland, and Frets on Heredity of Head Form bring out the fact that different limiting values must be used for men and for women in defining race type; the question of closer definition of type in women is receiving special attention.

R. M. F.

Heterozygoti og Legemshoide. By Waaler (Georg H. M.)—*Archiv f. Mathemat. og Naturvidenskab.*, 1923, XXXVIII, No. 6, 1–14.

"An examination of the heights of recruits in different parts of Norway shows, that the distribution of the average heights can be seen in connection with a theory by Dr. Andr. M. Hansen on the immigration of the peoples in Norway, when one besides this theory makes the hypothesis, that an increased heterozygosity has an increasing effect on the height. An examination in the battalions Valdres and Hallingdal with a part of Drammen battalion, where the theory with perhaps its best argument says, that two different races have met in the middle part of the battalions, and where therefore may be expected an increased heterozygosity, shows that these parts have a greater average height than the districts both above and below, in accordance with the hypothesis of the effect of heterozygosity."

A CONTRIBUTION TO THE MECHANISM OF GROWTH OF THE HUMAN FACE. By Keith (Sir Arthur) and George G. Campion—*Dental Record,* Feb., 1922, XLII, No. 2.

The authors "regard enlargement of the tonsils, the growth of adenoid vegetations in the naso-pharynx, and disordered or irregular growth of the jaws and face as manifestations of a single pathological state. What the exact nature of this underlying pathological condition may be they are not yet in a position to decide, but keeping in mind the close relationship there is between bone-formation and bone-growth, and the action of the glands of internal secretion on the one hand and the frequency with which a hypertrophy of the lymphoid system is accompanied by a defective formation of bone on the other, it is not difficult to believe that irregularities of the jaw and the development of adenoids may result from a nutritional disturbance. The explanation may come through the kind of research now being conducted by Colonel McCarrison, who has shown that a diet deficient in certain vitamine constituents will affect the normal working of the hormone growth systems of the body. Vitamines appear to act directly on the glands of internal secretion." The authors "suspect that the defects which are so frequent in the growth of the English, or rather Nordic, face may ultimately prove to be the result of some deficiency or error in the dietary on which our infants and youths are reared. No doubt, too, our modern dietary is of a kind which leaves teeth, jaw and muscles of mastication imperfectly exercised. The physical stimuli which are necessary for the normal growth of bone are missing. This, too, may be a factor in gnathic degeneration."

SOBRE ALGUNAS CORRELAÇOES FACIAIS. By Athayde (Alfredo)—Repr. from *Trab. Soc. Portug. de Anthrop. e Etnol.,* I, No. 4, Porto, 1922, 8°, 19 pp.

The paper, based on measurements of 228 Portuguese skulls deals with correlation of upper facial and nasal, the facial and orbital, and of the nasal and orbital indices in the two sexes; and also of that of the absolute facial measurements. As to the latter, the closest correlation is observable between the facial and nasal height, and after this, between the breadth of the face and breadth of the orbit; it is less between the heights of the face and orbit, and especially between nasal and orbital breadth.

STUDIEN UBER VERGLEICHENDE ANATOMIE IM VERHALTNIS ZUR OTOLOGIE. By Perez (Fernando)—repr. fr. *Monatsschr. f. Ohrenh. u. Laryngo-Rhinol.*, 1922, LVI, No. 4, 8°, 37 pp.

The author endeavors to show that the true "horizontal" level of the skull in man as well as other mammals, is that in which there is the least exertion of the muscles sustaining the head, and in which at the same time the auditory apparatus finds itself in the best position. This "horizontal vestibionlevel" which differs somewhat from both the Broca's and the Frankfurt levels, is ascertainable on all skulls though only by exposing the semicircular canals.

VARIATIONS IN THE REGION OF THE FORAMEN MAGNUM. By Harrower (Gordon)—*J. Anat.*, Jan. 1923, LVII, pt. 2 178–192.

After describing numerous cases of fusion of atlas (mostly imperfect) with the occipital and other anomalous conditions about the foramen magnum, the author concludes that: "No one questions the fact that the occipital bone is the product of one or more spinal segments, and skulls frequently give indications of the vertebral origin of the occipital region by the presence of such bony formations as a posterior arch, posterior tubercle representing a spinous process, third condyle (but I suggest only in those cases in which the dens of the axis is particularly long and articulates with the anterior margin of the foramen magnum), condyloid tubercle, sulcus ambiens between the pharyngeal tubercle and the anterior border of foramen magnum, and sulcus lateralis. I believe, however, that when the abnormality is such that an additional vertebra is indicated, the case is always one of assimilation of an atlas as the series I have described shows, never of a throwing-out of an occipital vertebra."

TEETH AND JAWS

THE ORIGIN AND EVOLUTION OF THE HUMAN DENTITION. By Gregory (William K.)—Baltimore, 1922 (Williams & Wilkins Co.) 548 pp., 353 figs.

"Parts I to V of this book were published in five successive numbers of the *Journal of Dental Research*, Vols. II and III, beginning in March 1920. The purpose of the book is to give a brief and concise review of the origin and evolution of the human dentition from the palaeontological viewpoint;. . .The facts and interpretations of facts here set forth are such as have presented themselves during the course of the author's palaeontological studies at Columbia University and at the American Museum of Natural History."

The book is difficult of reviewing or even of abstracting. It is a long record of able and conscientious studies in the phylogeny of primate, including human, teeth. If it is not complete or does not throw all the light that is wanted on the great and very complicated subject it deals with, the fault is not with the author but with the material. The utilized material is richer than that hitherto available to any other student, yet compared with what is needed it is a mere irregular sprinkling of specimens, often difficult to appraise or connect, with many stages and especially the "ur-forms" of man, of any individual primate, of the primates as a whole, still missing, and with the histo-morphology of teeth still insufficiently understood.

Doctor Gregory devotes himself particularly to the theory of the tritubercular ancestral type of the crown of the higher mammalian teeth. With Cope, Osborn and others, he accepts trituberculy as the fundamental cusp form, but in detail his conclusions are in advance of those of the earlier authors, formulating the following principles (p. IX): u (1) In the triangular upper molars of early Tertiary mammals there are two principal "trigons" (a) the *primary trigon*, consisting of the divided "original tip" (para + metacone) and the external cingulum, and (b) the *secondary trigon*, comprising the inwardly grown "protocone" and the divided original tip. (2) The homologue of the trigonid of the lower molars is not the *secondary* but the *primary* trigon. It follows from these principles, and from the studies of the occlusal relations of the upper and lower teeth, that Cope's conception of the origin of the tritubercular molar and, consequently, the whole nomenclature of the mammalian molars proposed by Professor Osborn, probably rest upon a misconception, by which the *secondary* trigon of the upper molar was viewed as corresponding with the *primary* trigonid of the lower molar."

The treatise itself is divided into five parts, namely: Stages of Ascent from the Silurian Fishes to the Mammals of the Age of Reptiles; Stages of Ascent from the Paleocene Placental Mammals to the Lower Primates; Nature's Earlier Experiments in Evolving Large-Eyed and Short-Jawed Primates; The Dentition of the Higher Primates and their Relationships with Man; Later Stages in the Evolution of the Human Dentition; with a Final Summary and a Bibliography. Of these sections that dealing more directly with man is, at least to anthropology, of the greatest interest. It is also the one that will soonest necessitate a rewriting, for here much, necessarily, is still uncertain. It is interesting to follow the author's thoughts in which there is much that is sound. Nevertheless this chapter and particularly its "Conspectus" (p. 480 *et seq.*) with parts of the "Summary" (*e. g.*, (25), p. 520) need a revision and will doubtless receive same more than once as evidence accumulates and crystalizes. As it is, our evidence concerning early and even recent man is not only very imperfect, but is encumbered by much dross.

A Manual of Dental Anatomy Human and Comparative. By Tomes (Sir Charles S.)—8°, N. Y. (The MacMillan Co.), 1923, 547pp., 325 fig.

The popularity of this work can be gauged by the frequency with which the editions appear. The wide-spread demand for it is justly deserved; it is a work without which no library is complete and which no student can afford to ignore.

The present, eighth, edition is edited by H. W. Marett Tims assisted by C. Bowdler Henry. In this edition "the amount of new material" as indicated in the preface "is less than it might otherwise have been." For the cause of it the editor blames the European War which "has waged over the greater part of the period since the publication of the seventh edition." On account of this, the editor claims, the output of new investigations into the structure and comparative morphology of the teeth, was diminished. Whether this is meant as a general statement or as pertaining to England alone is not quite clear. In the former case the extensive and important investigations and contributions during this period made in the United States must have been overlooked.

In the chapter on "The Teeth of Man" the terminology adopted is evidently an innovation. Undoubtedly the editor considers it an improvement. Thus the captions, for example, read: "The First Upper Incisors," "Second Upper Incisors," "The First Mandibular (Lower) Incisors," "The Second Mandibular Incisors," "The Maxillary Canines," "The Mandibular Canines," etc. It is not clear why the upper canines are called maxillary canines, and why the upper incisors are not called premaxillary incisors? Moreover, it is not quite clear why the *permanent* premolars are distinguished as maxillary and mandibular while the "deciduous predecessors" are termed "The first deciduous upper" or "Lower premolar." Also in the description of "The Arrangement of the Teeth in the dental Arches" the editor forgets or overlooks the new terminology when he says that "The teeth in the *upper* jaw are arranged along a curve of larger dimensions than those of the *lower*," etc., and later (p. 29) "The *upper* canines close over the halves of the *lower* canines and first premolars."

In the chapters on dental tissues the editor is at a better advantage. Both in descriptive and illustrative material there is a wealth of information. A very comprehensive knowledge is gained on the structure and variety of enamel, dentine, cementum and Nasmyth's membrane. The human and comparative view-points are well presented. The "Gum" and "Alveolo-Dental Membrane" come in for a thorough consideration. Descriptions of these tissues are abundantly supplemented by quotations and illustrations from various authorities recognized in this particular field of work. The chapter on "The Development of the Teeth" deserves special mention, as it covers the subject in a brief but clear manner, bringing into the foreground the most representative and recent contributions on the subject.

In the chapter on calcification of the dental tissues the various prevailing views are duly accredited. Thus, referring to the calcification of enamel, the two foremost views are mentioned. One is "That it is formed by the actual conversion of the cells of the enamel-organ into enamel," and the other, "that it is in some sense secreted or shed out by these cells." But the problem seems to be far from being settled because "notwithstanding all that has been written upon the subject of enamel development, the problem is so difficult that some doubt still remains as to the exact *modus operandi* of the enamel cells." Regarding the origin of enamel there is a detailed description of the various opinions, theories and convictions. The conclusions reached are based on a provisional grouping of the "different methods of enamel formation;" thus, "(A) Enamels which are not wholly epiblastic" and "(B) Enamels which are wholly epiblastic. By this grouping it is attempted to show that there is "an increasing specialization and importance of the ameloblasts, which at first only take a share in the result and afterwards effect the whole process unaided."

The process of dentine formation and calcification and variation is similarly thoroughly treated and ought to be a great attraction to those interested in this problem. The cementum is also well dealt with. This is followed by a concise chronological history of ontogenetic development of the dental lamina and the dental papillae. The data upon which reliance is placed is obtained from Röse's tables.

The development of the jaws and eruption of the teeth is treated in the usual manner. No attempt is made to upset the established principles and beliefs that have come down since the time of Hunter. In the chapter on the succession of the teeth, considerable detail is gone into with the purpose of a thorough exposition of the knowledge recently gained. Also Bolk's new conception of the process in reptiles is concisely and clearly stated. Thus, as has hitherto been customary, the teeth of the reptiles were considered as belonging to one row, a condition termed by Bolk *monostichical*. It is Bolk's opinion "that the teeth, though standing in a single row, must be regarded as belonging to two rows, the individual teeth of which have secondarily become interpolated alternately between each other." For this reason "they are not. . .replacing teeth in the true sense of the word. Bolk, moreover, "thinks that the dental system must have been originally *tristichical*, the outer row having become rudimentary, though aborted representatives may still be present in some of the living reptiles. These last are termed the *parastichos*, the middle and inner of the three parallel rows the *exastichos* and *endostichos*, respectively. . . The process of tooth replacement in reptiles Bolk regards as a totally different phenomenon from that which occurs in mammals; hence, the diphyodontism of the latter is not to be derived from the polyphyodontism of the former. The typical difference is that the functioning teeth of the reptiles comprise members of two series (i. e., exastichos and endostichos),. . .whereas in mammals the two rows function one after another." It is only just to state that these views have been attacked very strongly by various authorities.

The chapter on the "Evolution of the Tooth Forms" is replete with the various theories advanced to explain the metamorphosis of the single cusped tooth to the complex multicusped molar of mammals. After citing the cusp differentian theory advanced and supported by Cope and Osborne, the concrescence theory of Kükenthal and Röse and the cingulum theory of Marett Tims, prominence is given to the Bolk "Dimer Theory." The description of the first of these theories appears to be lacking the evidence of more recent investigations. As a result, it appears obsolete and unconvincing. The Bolk theory, on the other hand, seems to find more favor, i.e ., there is little objection manifested. In the opinion of the palaeontogist Bolk's theory is fundamentally a form of the concrescence theory and like the other forms, it is based chiefly on an erroneous phylogenetic interpretation of certain ontogenetic facts. In the words of Gregory, "His peculiar hypothesis is that every tooth from the incisors to the last molars, represents a 'dental family' of two (or more?) successional tooth germs, and consists of two parts: an outer, labial or buccal part, called protomere; and an inner or lingual part, the deutomere. From various indications among modern mammalian teeth, protomere and deutomere are each inferred to be potentially equivalent to a triconodont crown, so that every tooth potentially or actually carries six primary cusps." The evidence furnished by paleontology, however, fails to prove such contention. On the contrary, it bears sufficient proof for the conviction that "in the long series of forms that stand in or near the line of human ascent, from rhapsidian fishes up through the primitive amphibians and reptiles to mammal-like reptiles, thence through the Mesozoic trituberculates to Eocene primates there is not one whose incisor or any other teeth, conform to Bolk's ideal pattern "(Gregory). Moreover, "the four classes of teeth, incisors, canines, premolars and molars, were more or less differentiated from each other, not only in the earliest Lower Eocene primates but in the vastly older Mesozoic trituberculates and even in the higher mammal-like reptiles." (Gregory). From these statements it may be gleamed that too much credence must not be given to the validity of this theory fascinating as it is.

The rest of the book is given to anatomic description of the mammalian teeth. The teeth of the Monotremes, Marsupials and Placental mammals are dealt with, as are also those of early man. Reference to the Rhodesian skull and the Galley Hill man is made in the concluding chapter; and certain distinctive features in teeth are associated with different races of man.

The book as a whole is well gotten up and printed; it is also profusely illustrated and the material is well arranged, for all of which the Editor and Publishers deserve due praise.

Milo Hellman

Nutrition, Growth and Dentition. By Hellman (Milo).—*Dent. Cosmos*, Jan., 1923.

"The process of dentition is a physiologic manifestation of growth and is subservient to its variations in rate, acceleration and retardation. The acceleration in body growth may be accompanied by a retardation in the process of teething and *vice versa*. Excessive retardation in body growth may result in diminution in size. Excessive retardation in dentition may result in abnormal position and consequent malocclusion. It may therefore be concluded that nutrition has a direct, positive and stimulating effect upon body growth as a whole, but it appears that the acceleration in body growth has an adverse influence upon the process of dentition."

DENTAL AGE AS SIGN OF TOTAL DEVELOPMENT (In Czech). By Matiegka (J.)—*Biolog. Listy*, Praha, 1922, VIII, 81–84.

Basing his conclusions on extended observations made on children of Prague, the author shows that in general there exists a rather close correlation between the state of dentition and the weight and stature of the individual.

UEBER DIE MEHRFACHE ANLAGE DES ZWISCHENKIEFERS BEIM MENSCHEN. By Jarmer (K.)—Zeitschr. f. Anat. u. Entwicklungsgesch., 1922, LXIV, 56–75.

The old problem of the development of the intermaxillary bone in man has received a new contribution. The author (who regrettably has omitted to consider the recent work by Felber on this question) reaches the conclusion that the incisivum is derived from three distinct centers on each side: a corpus, a palatinal part, and a center situated medially to Jacobson's organ which later participates in the formation of the anterior nasal spine. Among other results may be mentioned that the palatinal portion of the mammalian intermaxillare is not comparable to the part bearing that name in man but to the so-called processus Stenonianus in the latter.

A. H. SCHULTZ.

VERÄNDERUNGEN IM KIEFERGELENK DER NEU-KALEDONIER UND LOYALTY-INSULANER UND IHRE BEDEUTUNG FÜR DIE ZAHNÄRZTLICHE PROTHESE UND ORTHODONTIE. By Schwarz (R.)—Schweiz Monatsschr. f. Zahnheilk., 1922, XXXII, 373–389.

In a large series of skulls from New-Caledonia and the Loyalty Islands, it was found that, even at a comparatively early age, the teeth were very much worn down, the capitulum mandibulae becoming pressed to an unusual degree against the fossa glenoidalis. In these natives the movements of the lower jaw during mastication are chiefly in an anterior-posterior direction. These conditions result in a broadening of the capitulum and in corrosions as well as excrescences on both the glenoid fossa and the condyle of the mandible. At times even sagittal grinding grooves are found on the capitulum. The tuberculum articulare is very little developed and in many cases entirely missing, which, in the author's opinion, may be due to the wearing away of this structure during mastication.

A. H. SCHULTZ.

DEFECTIVE DEVELOPMENT OF THE MANDIBULAR ARCH. By Gladstone (Reginald J.) & Cecil P. G. Wakeley—*J. Anat.*, Jan, 1923. LVII, pt. 2, 149–167.

The article deals with "The Etiology of Arrested Development and an Inquiry into the Question of the Inheritance of Congenital Defects."

The main conclusions are "Direct inheritance of ante-natal deformities appears to be the exception rather than the rule. In 554 cases of hare-lip and cleft-palate we found only two in which it was recorded that the deformity was present in one of the parents. Ante-natal *defects of development* appear to be the result of the same conditions which in some subjects may produce defect in growth, after as well as before birth, for instance deformities of bone in rickets or craniotabes in syphilis. We believe that the defects in growth of the face and lower jaw are usually associated etiologically with defective development of the brain; for instance cyclops with defective growth of the fore-brain; otocephaly and agnathia with maldevelopment of the hind-brain."

STUDIES ON THE ETIOLOGY OF ANGLE'S CLASS II MALOCCLUSAL MANIFESTATIONS. By Hellman (Milo)—Int. J. Orthodont., 1922, VIII, No. 3 (repr. 8°, 20 pp.)

"Irregularity of the teeth or of any other organ is a biologic phenomenon and may occur in all living things; malocclusions due to irregularities of the teeth, like the disturbed functions due to irregularities of other parts of animals and plants, are biologic phenomena; attempts at classifying the irregularities and malocclusion of the teeth have been made as early as 1803; these attempts terminated in the simple classification worked out by Angle which is accepted throughout the world; the basis of Angle's classification does not prove satisfactory with respect to the divisions of Class II manifestations; malocclusion is essentially an expression of some discrepancy in growth; growth, though occurring as a constant manifestation from the fertilization of the egg to the adult size of the individual, is modified by retardations and accelerations; retardations and accelerations associated with growth, influence the formation and completion of the masticatory apparatus as they do everything else that depends upon growth and development for its perfection; accelerations and retardations when influenced by pathologic conditions result in deformities."

DENTAL CARIES AND RACE. "Dr. Shafer, dental director of the Standard Oil Company, has gathered and Dr. A. W. Schoenleber of the medical department has sent us data on the dental condition of 2,758 men, classified by nationality. The dental conditions are graded into 4 grades (with certain subdivisions):

Grade 1, Perfect to excellent, 236 or 8.6 per cent of all.
Grade 2, Serviceable, 804 or 29.2 per cent of all.
Grade 3, Probationary (16 or less teeth), 1,638 or 59.4 per cent of all.
Grade 4, Rejected on account of oral conditions, 78 or 2.8 per cent of all.

Compared with this standard for *all*, the grade for some of the better represented nationalities are as follows:

	Italians		Polish		Am. Negroes		Austrian (Jews?)		Irish	
	No.	%	No.	%	No.	%	No.	%	No.	%
Grade 1	52	18.6	14	12.1	8	20.5	18	11.0	4	3.2
" 2	52	18.6	27	23.3	6	15.4	40	24.4	36	29.0
" 3	169	60.4	71	61.2	24	61.5	104	63.4	67	54.0
" 4	7	2.5	4	3.4	1	2.6	2	1.2	17	13.7
Total	280		116		39		164		124	

These statistics, so far as they go, and assuming that there was no unconscious or conscious selection of the candidates from the different nationalities, lead to the following conclusions: It appears probable that there is a racial difference in resistance to dental caries. The American Negroes and Italians have the largest proportion of perfect teeth. The Polish and Austrians (largely Jews?) rank next and the Irish come last with the smallest proportion of excellent and satisfactory teeth and the highest proportion of rejection on account of bad teeth. The total of English, Germans, Danish, Norwegian and Swedish amounts to 99 persons. These are classified in the four classes respectively as 3, 33, 54 and 10 per cent. The rates run only a trifle better than the Irish. Evidently feeble resistance to dental caries is a Nordic trait." *Eugenical News*, June, 1922, 70–71.

THE DECAY AND LOSS OF TEETH

The molar teeth are obviously the most important organs of mastication and their decay and loss are often serious causes of ill health.

An investigation of the teeth of 5,000 employees in two different industries showed that 47 per cent of all first molars, 17 per cent of all second molars and 14 per cent of all second pre-molars were lost. This is equivalent to a loss of over one-half of the masticating efficiency of these workers. This condition is, in the judgment of expert dental authorities, fairly typical among adults and shows to what extent mastication and digestion may be interfered with through the impairment of the dental tissues.

Dr. Thaddeus P. Hyatt, Dental Director of the Metropolitan Life Insurance Company, has recently completed a study of the condition of the teeth among 8,068 pupils of different high schools in the City of New York which throws further light on this subject. He found that 15 per cent of all the first molars were already missing among these high school children. Of the second molars, two per cent were missing and of the second pre-molars two per cent were missing. The older the children, the larger the proportion of missing molar teeth.

Equally important is the result of Dr. Hyatt's study on the dental surfaces which are most prone to decay. Thus, on the first molars of these school children, it was found that 62 per cent had cavities on the grinding or occlusal surface; 18 per cent had cavities on the front or mesial surface; 16 per cent had cavities on the back or distal surface; five per cent had cavities on the outside or buccal surface; and only two per cent had cavities on the inside or lingual surface.

Much the same situation is found on the other molar teeth examined. Thus, of the second molars, 45 per cent had cavities on the grinding surface. The other surfaces showed never more than three per cent of the surfaces with cavities. On the second pre-molars, 11 per cent had cavities on the grinding or occlusal surface; the other surfaces showed relatively small proportions of the surfaces decayed.

Dr. Hyatt concludes that at least 75 per cent of the initial decay which results in the ultimate loss of molars begins on the occlusal or grinding surface. For preventive dentistry to become practical and effective, some procedure must be found which will reduce the susceptibility of the grinding surface to decay. This problem is now seriously engaging the attention of the dental profession.

The above findings are all the more important in view of the large number of children who show serious defects of the teeth even at the earliest ages. Studies of New York City school children showed defective teeth in 96.5 per cent of all examined, with an average of nearly seven cavities per child. Any discoveries of methods which will prevent decay will certainly play a large part in maintaining the health and vigor of growing children.

—Statistical Bulletin, Metropolitan Life Ins. Co., December, 1922, III, 6–7.

Über die künstliche Deformation des Gebisses bei den Steinzeitmenschen Japans. By Koganei (Yoshikiyo).—*Proc. Medic. Faculty I. Univ. Tokyo*, 1922, XXVII, 429–485, 7 pl.

An elaborate paper showing artificial modifications of the denture in the neolithic people of Japan. The effects produced were the removal of the canines or incisors (or both) and the filing of the upper incisors. The filing was of the trident type found also in America (*e.g.* among the Tarasco, in Mexico); the ceremonial removal of some of the front teeth was also quite common on this continent.

ERRATA

In Prof. A. W. Meyer's article on "The Cervical Fossa of Allen" in the preceding number of this JOURNAL Figures 1 and 7 should change places, and the legend under Figure 9 should read "A transitional form of *eminentia articularis colli femoris*" instead of "A transitional form of *fossa articularis colli femoris*".

American Journal of Physical Anthropology

Volume VII OCTOBER–DECEMBER, 1924 Number 4

THE HUMAN JAW-BONE FOUND AT FOXHALL

SUFFOLK, ENGLAND

J. REID MOIR

In view of the great amount of interest shown—especially by American anthropologists—in the human jaw-bone discovered at Foxhall, Suffolk, England, in 1855, and as some people appear to regard this discovery as affording, in itself, evidence of the existence of Tertiary Man, it is as well, perhaps, that an unbiased presentation of all the facts relating to the finding of this relic should be laid before the readers of the American Journal of Physical Anthropology.[1]

The Foxhall human jaw-bone was said to have been found at the depth of 16 feet from the surface in an ancient marine deposit, the "Red Crag," which covers a large area in East Suffolk. At the time of the discovery, the Red Crag was being excavated extensively in order to recover, for commercial purposes, the rolled lumps of phosphatic clay called "coprolites," occurring in a remarkable deposit at its base and known as the Suffolk Bone-bed. It was at this period, when large tracts of Crag were being turned over, that the bulk of the collections of sub-Crag fossil bones and teeth of *Mastodon*, and other mammals, was made, and it was owing to the fact that the coprolite diggers were rewarded for any specimens they might find, that the Foxhall jaw-bone was preserved for scientific examination.

In the *Anthropological Review* there is to be found a paper entitled "The Fossil Human Jaw from Suffolk" by R. H. Collyer, M. D., and the main points of this, the original account, may be summarised as follows (the numbers of the pages given refer to those in the volume of the *Anthropological Review*:

P. 221. "At the instigation of Vice-Admiral Sir Edward Belcher, C. B., I was induced to exhibit to the Ethnological Society of London, in April, 1863, a fossil or coprolite jaw, which was found by the workers employed in excavating coprolites near Ipswich, Suffolk. The jaw was purchased from the finder by Mr. John Taylor, druggist of Ipswich, for the sum of 2/6, who called my attention to it at the time, 1855. The specific gravity (of the jaw bone) is much greater than that of a recent bone of the like size, it being infiltrated throughout its entirety with oxide of iron, and the surface presents peculiar metallic lustre. I have now every reason to believe that this coprolite jaw is the oldest relic of the human animal in existence, as its condition corresponds in every respect with the coprolites in whose contract it was found."

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[1] For the original papers upon this question see:—Collyer (R. H.)—The Fossil Human Jaw from Suffolk, '*Anthropological Review*,' 1867, V., 221–229. Moir (J. Reid), *Proc. P. S. E. A.*, III, Part III, 389–430.

Taylor presented the jaw bone to Sir Thomas Beavor Bart[2]., of Norfolk, in whose possession it remained until March, 1857, when he forwarded it to Collyer. Collyer took it to his friend Professor Quekett, then Curator of the Royal College of Surgeons, London, who showed it to Professor Owen. The latter gentleman (p. 222) "kept it for two years without coming to any expressed opinion." In 1859 Collyer took the bone to Prestwich. In April, 1863 (p. 222), "in consequence of Sir Charles Lyell's work on 'The Antiquity of Man,' I wrote to Professor Huxley a short history of the 'coprolite jaw.' In the meantime Sir E. Belcher called on me, stating that Mr. Crawford was going to read a paper on 'The Primitive Races of Mankind' at the Ethnological Society, and urged me to accompany him, and bring the 'coprolite jaw.'

"After the paper, a discussion took place, in which Sir C. Lyell, Sir Roderick Murchison, and Professor Busk took part." The latter stated that Collyer's specimen was "the jaw of some old woman, perhaps from some Roman Burial Ground." Huxley called upon Collyer the morning after the meeting, and pronouncing the jaw-bone to be a "most extraordinary specimen" took it away with him and handed it to Busk for examination. Finally, Huxley wrote to Collyer stating (p. 223) that the jaw-bone showed "some peculiar characters," which, however, did not appear to him to be in themselves adequate to lead him to ascribe the bone "to an extinct or aberrant race of mankind, and the condition of the bone is not such as I should expect a Crag fossil to be."

P. 223. The "coprolite jaw" was taken by Messrs. Busk and Falconer to Paris, and on p. 37 of the *Natural History Review*, July, 1863, they published the following signed statement:

> "The specimen is a very remarkable lower jaw of a human subject now belonging to Dr. Robert H. Collyer. It is reputed to have been found in the gravel heap of a coprolite pit near Ipswich. Although retaining a portion of its gelatine, it is infiltrated through and through with iron. The Haversian canals are filled with red oxide, and a section of the fang shows that the ivory is partly infiltrated with the

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[2] Sir Hugh Beavor, of Hargham Hall, Attleborough, Norfolk, informs me that he cannot remember having seen any jaw-bone in the collection of fossils belonging to his grandfather the late Sir T. Beavor.

same metal. This specimen proves that the human jaw, if favourably placed, is equally susceptible of impregnation with metallic matter as the bones of any other mammal.

"Signed:—
H. FALCONER
G. BUSK"

P. 227. Busk wrote to Collyer, after examining the jaw-bone, to the effect that he wished to "considerably" modify the opinion he "hastily expressed at the Ethnological Society." "That is to say, it is very different from an ordinary church yard bone, though, of course, without any relation as regards age with the fossil bones of the coprolite beds; it is of very great antiquity, and it is peculiarly remarkable for the great amount of iron it contains, though still retaining about 8 per cent of animal matter." And regarding this statement Collyer remarks (p. 228): "Nothing more could be expected from Professor Busk; when he says the coprolite jaw is of very great antiquity, he admits the whole question."

On November 13th, 1886, Taylor wrote to Collyer from 97, Fore Street, Ipswich, as follows:

"*Dear Doctor:*

I was very agreeably surprised to hear from you this morning. If I had known you were residing in Boulogne-sur-Mer, and had possession of "the jaw," I would have called upon you on my way to the Pyrenees last year, in order to have had another good look at the bone, which certainly must be of the same age as the coprolite in which it was found. The history of the matter, so far as I know, is very short. From what I could learn at the time, from the agricultural labourer of whom I bought it, it came from the coprolite pit on the farm of Mr. Laws at Foxhall, about four miles from Ipswich, and was thrown out at Mr. Packard's manure factory with the coprolite from a cart or tumbril, and from thence was brought to me to secure a glass of beer. I had possession of it for near three months, when Sir Thos. Beaver, (whose son was then living with me) called on me, and seeing that he exhibited great interest in the inquiry as to the antiquity of the jaw, I had the pleasure of presenting him with it. There is no doubt the bone was obtained at some depth, as I know the pit had been open for a considerable time when it was found.——————."

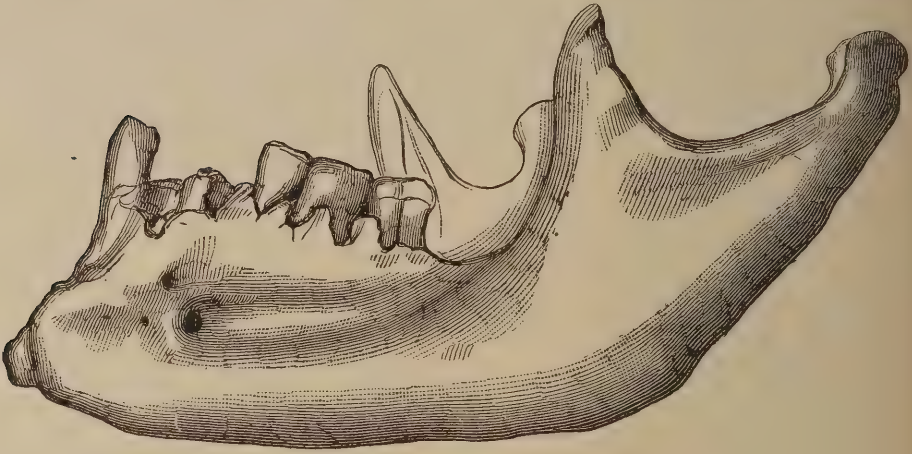
Yours very truly,
J. TAYLOR

DR. COLLYER

P. 228. Collyer adds the following note; "I visited the coprolite pit in 1855, immediately after it (the jaw-bone) was found and ascertained that it had been worked for over a year. The place from which the jaw in all probability came, was sixteen feet below the surface." The paper closes with the following expression of opinion by Collyer (p. 229); "I see no reason whatever for doubting the antiquity of the coprolite jaw." Accompanying the paper is an illustration of the jaw-bone described.[3] (Fig. 1).

From the above summary of Collyer's paper it will be realised that the Foxhall jaw-bone was carefully examined by competent palaeontologists. It is clear also that Collyer was at pains to place before the scientific world an unprejudiced account of the facts regarding the discovery.

When I first read the paper published in the *Anthropological Review* I could not understand how it came about that a coprolite bed occurred at Foxhall at 16 feet from the surface, as my investigations had led me to believe that the coprolitic stratum was generally to be found at a depth of from 25 to 40 feet from the surface in this district. But, on consulting the Geological Survey Memoir of the district, "The Geology of the Country around Ipswich, Hadleigh & Felixstowe", I found to my surprise that, on p. 62, the occurrence of a nodule-bed *lying in the Crag itself* (in addition to the normal one at its base) was noted in a pit just south of Foxhall Hall, and that this nodule-bed rested at a depth of 16 feet below the surface. The exact correspondence—so far as depth from the surface is concerned—between the nodule-bed mentioned by



THE FOXHALL JAW BONE

(Reproduced by permission of the Royal Anthropological Institute of Great Britain and Ireland, and of the Prehistoric Society of East Anglia).

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[3] In his "Antiquity of Man" (p. 200), Keith gives an outline drawing of the Foxhall jaw-bone and remarks that it is of the "modern" type, as compared with the same bone of the Neanderthal species of man.

Collyer and that described in the Survey Memoir, caused me to make further enquiries regarding the *locale* of "Mr. Law's Farm," mentioned by Collyer as being situated in the parish of Foxhall.

Fortunately the present occupier of Foxhall Hall was able to give me very definite evidence upon this point, for upon the matter being mentioned to him, he at once intimated that "Mr. Law's Farm" was that now known as Foxhall Hall. The enquiry being thus narrowed down I decided to investigate the nodule-bed mentioned as occurring in the old pit near the Hall, and, as is widely known, my investigations resulted in the discovery of what appears to be a definite occupation level at this horizon, containing cores, flakes, flint implements, and a number of stones exhibiting crackling and other evidences of having been subjected to the action of fire. The Foxhall area was very much dug over in the old days when coprolite was being raised, and it is almost certain that—during the diggings—seams of phosphatic material were found at a depth of sixteen feet below the surface, on Mr. Law's Farm, at places other than that at which I conducted my investigations.

But it must be admitted that the exact agreement of Collyer's statement with that published in the Survey Memoir, and the unique discovery (so far as the Crag is concerned) of an apparent living site at the sixteen foot level, where a human jaw-bone might very well occur, is not without significance. In 1855, when the discovery of the Foxhall jaw was made, the Geological Survey of the district under discussion had not been undertaken, nor was it known until 1919 that any humanly-flaked flints occurred in the nodule-bed at the sixteen foot level. So that each of the three statements regarding this horizon, though quite independent one of the other, yet, nevertheless, support each other in a remarkable manner. Further, when reference is made to Collyer's description of the condition and appearance of the Foxhall jaw-bone, it is seen that it was evidently not in the highly mineralised condition of the majority of the bones found in the sub-Crag detritus-bed.

It is clear, also, that Collyer was struck by the "peculiar metallic lustre" attached to the surface of the bone. I am very familiar with this lustre, which is common upon sub-Crag specimens of various kinds, from different localities (bones, stones, coprolite etc.), and may be seen also upon some flints found in the Middle Glacial Gravel of the Ipswich district. Though this is the case, I have never observed specimens exhibiting such a marked metallic lustre, giving them the appearance of having been black-leaded, as is to be seen upon many of the relics found at the sixteen foot level at Foxhall Hall. This highly lustrous appearance of many of the specimens was, in fact, a characteristic feature of the stratum under discussion. And here again it would seem to be significant that Collyer draws especial attention to a particular phenomenon which has now been proved to be frequently met with in the pit at Foxhall.

A quantity of bones, in a fragmentary condition, were found during the excavations, and the vast majority of these do not exhibit the advanced state of mineralisation such as is exhibited by many sub-Crag specimens. A few examples of the latter type of bone were found, and these were quite easily differentiated from the former variety. The majority of the bones from the Crag preserved in public and private collections have been derived from the basal detritus-bed, and are highly mineralised. But, for many years past, it has been recognised that two well-defined varieties of bones (so far as their condition of fossilization is concerned) occur below the Crag. In the *Survey Memoir* already mentioned (pp. 102–103), Herapath states this fact very clearly. He writes: "The majority of these bones which I have examined were obtained from the neighbourhood of Sutton. The sample evidently consisted principally of bones of extinct cetaceans: and the fossils could readily be divided into two classes, according to the appearance they presented. The bones of the first class (a) were very frangible, and possessed a somewhat porous and spongy texture, caused by the existence of numerous minute cavities or air-tubes in the substance of the bone; whilst those of the second class (b), on the contrary, were very solid, and possessed a fibrous structure." There can be little doubt but that, so far as their condition is concerned, the Foxhall specimens correspond to those of Herapath's Class A. and, in view of the fact that the jaw-bone described by Collyer was rejected, principally, because it contained about 8 per cent of animal matter, and did not appear to be in the same condition of most of the sub-Crag bones (it seems probable that a comparison was made with the heavily-mineralised specimens such as Herapath describes under Class B). I sent a representative sample of the Foxhall bones to Messrs. E. Packard & Co. Ltd., of Bramford, Ipswich, who examined these specimens and forwarded to me the detailed analysis, which is given below:

RESULT OF ANALYSIS OF MAMMALIAN CRAG BONES FOUND AT THE 16 FOOT LEVEL IN THE PIT AT FOXHALL HALL

	1	2	3	4	5
Moisture	3.76	3.05	3.50	3.60	3.45
Organic Matter	6.23	6.50	6.25	6.20	5.55
Phosphoric Acid	30.22	29.51	28.59	30.83	31.11
Phosphate of Lime	65.97	64.42	62.41	67.30	67.91

The above figures demonstrate that some of the specimens found at the 16 foot level in the pit at Foxhall Hall, contain as much as 6½ per cent of organic matter. It will be remembered that the Foxhall jaw-bone contained about 8 per cent of this latter material, and its antiquity was regarded with scepticism in consequence. The above mentioned analysis shows that the organic content of the specimens found at the geological horizon at which the jaw-bone in all probability occurred is, to all intents and purposes, coincident with that of the jaw-bone itself.

These are the facts regarding the discovery and alleged provenance of the Foxhall jaw-bone. Unfortunately, the specimen—like a number of other similar relics which could be mentioned— was not seen *in situ* by any competent person. Further, the diggings carried out in 1919 failed to reveal any bone which was comparable, so far as completeness goes, with the Foxhall jaw. All the specimens were fragmentary, and so fragmentary as to be unidentifiable. Nevertheless I feel that, in view of the obvious seriousness of Collyer's paper in the *Anthropological Review*, and the remarkable series of mutually supporting facts (which it is difficult to regard as mere coincidences) set forth in the foregoing pages, I have been justified in drawing attention to this matter.

When Collyer brought the Foxhall specimen before the scientific world, the minds of most archaeologists were not prepared to regard favourably the idea of the existence of Pliocene man. The acceptance of the human origin of the now universally recognised flint implements of the Early Palaeolithic periods was, in 1867, by no means general. The existence of humanly-fashioned flints, below the Red Crag—and at Foxhall, where the jaw-bone was found—was unknown, and Collyer's claim of a Pliocene antiquity for his specimen would naturally be received with considerable scepticism. I am of the opinion that if the Foxhall jaw-bone could be re-examined now, it would be possible to say with considerable certainty as to whether it was derived from the Crag, or not.

But, unfortunately, the specimen cannot now be found, and advertisements placed by me in various newspapers, and other journals, have failed to bring it to light.

Owing to the kindness of the Acting Registrar to the *General Council of Medical Education and Registration of the United Kingdom*, I have been informed that Dr. Robert Hanham Collyer was registered in England on the 23rd of June 1868, with the qualification M. D., Medical College, Pittsfield, Massachusetts, 1839. His application for registration is dated the 23rd of October 1867, when he gave his address as, 40, Carlton Hill, St. John's Wood. At the time of his registration he was at 1, Norman Terrace, Stockwell, which he subsequently changed to 199, Brompton Road, S. W., which was his registered address in 1878, in which year his name lapsed from the Medical Register, in consequence of this address having been found to be inaccurate. According to the American Medical Directory, the College from which apparently he obtained his degree, is described as the Berkshire Medical College, Pittsfield, Massachusetts, an Institution which is classed with those which are extinct, or merged with other colleges. There is some reason to believe that Collyer returned eventually to America taking the Foxhall jaw-bone with him. It would seem unlikely, in view of the importance he attached to the specimen, that no instructions would be left by him for the preservation of the specimen after his death, and I have cherished the hope, not yet fulfilled, that the publicity given to this matter may result in the Foxhall jaw-bone being once more brought to light.

The above account makes it clear that, while there seems much probability for regarding Collyer's discovery as of considerable importance, the fact of this importance is not scientifically established. When all the circumstances of the case are considered, it is not possible to speak of the Foxhall jaw-bone as affording certain evidence of the existence of Tertiary Man, nor is it desirable or reasonable that the acceptance or rejection of the flaked flints found by me, under strictly scientific conditions, at the 16 foot level at this place, should be influenced by the specimen described by Collyer.

Of the great antiquity of the Foxhall flints there cannot be any doubt, they occurred at two well-defined layers in the Red Crag (which at this spot is covered by 10 to 12 feet of glacial gravel), and appear to indicate the existence of a temporary shore-line at this level, inhabited by people flaking flints to various simple forms and acquainted with the use of fire.

The Red Crag is generally regarded by English geologists as of Pliocene age—a view not shared by the majority of their French colleagues who relegate this deposit to the early portion of the succeeding Pleistocene epoch. Personally, for reasons put before me by Sir Ray Lankester, and from my own observations, I favour the French view. If this opinion is correct, and if the Foxhall jaw-bone was indeed derived from the 16 foot level in the Red Crag, it can only be regarded as of Early Pleistocene age, and not as a relic of Tertiary Man.

The detrital deposit, or bone-bed, occurring at the *base* of the Red Crag, in which I have found a number of flaked flints, accepted as of human origin, by most authorities, is, without question, of a much greater antiquity than the shelly Crag sands surmounting it, and may be relegated with confidence to the Pliocene period.

THE FOSSIL HUMAN JAW FROM SUFFOLK[1]

By Robert H. Collyer, M.D.

At the instigation of Vice-Admiral Sir Edward Belcher, C.B., I was induced to exhibit to the Ethnological Society of London in April, 1863, a fossil or coprolite human jaw, which was found by the workers employed in excavating coprolites near Ipswich, Suffolk.

The jaw was purchased from the finder by Mr. John Taylor, druggist, of Ipswich, for the sum of 2s 6d., who called my attention to it at the time, 1855. A small portion of the bone was filed off, which, on the application of heat, emitted a slight odour peculiar to burnt gelatine, showing conclusively that the whole of the animal matters of the bone has not been fossilized. As this to my mind is no criterion that the bone did not belong to a period coeval with extinct mammals, I was very anxious to become the possessor of this "coprolite jaw." The specific gravity is much greater than that of a recent bone of the like size, it being infiltrated throughout its entirety with oxide of iron, and the surface presents peculiar metallic lustre. The condyloid processes are one-and-half inches distant from the alae, and from the condyles to the posterior angular protuberance it recedes full 45°, and the same receding angle is shown from the mentum prominens to the alveolar processes of the place formerly occupied by the incisor teeth; the bone probably was that of a female of small stature, and as the alveolar portion of the jaw, where the incisor teeth were inserted, is closed, and the molar teeth ground down, I am of opinion that "the human" tore the food prior to mastication by the molars. The cranium of this jaw must have been very small, with a contracted low frontal region. I have now every reason to believe that this "coprolite jaw" is the oldest relic of the human animal in existence, as its condition corresponds in every respect with the coprolites in whose contact it was found. Mr. Taylor presented the "coprolite jaw" to Sir Thomas Beaver, Bart., of Norfolk, in whose possession it remained until March 1857, when he kindly forwarded it to me. I took it forthwith to my friend Professor Quekett who was then Curator of the College of Surgeons, who after having carefully examined it, said, "this is indeed a curious bone; it belonged to a very low race; I would wish Mr. Owen, of the British Museum to see it." I accordingly took it to Professor Owen, who kept it for two years without coming to any *expressed* opinion. In 1859 I took it to Mr. Prestwich.

In April, 1863, in consequence of Sir Charles Lyell's work "On the Antiquity of Man," I wrote to Professor Huxley a short history of the "coprolite jaw." In the meantime Sir E. Belcher called on me, stating that Mr. Crawford was going to read a paper on "the primitive races of mankind" at the Ethnological Society and urged me to accompany him and bring the "coprolite jaw."

After the paper, a discussion took place, in which Sir C. Lyell, Sir Roderick Murchison and Professor Busk took part. At this time the whole scientific world was very much interested in the discovery of the "Abbeville jaw" by M. Boucher de Perthes in the drift of the Somme Valley, in contact with flint haches or langues de chats.

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[1] As the original article on the Foxhall jaw is printed in a Journal which has long been extinct, and in order to present in a handy form all the details bearing on the specimen, it is thought best to reproduce here the original paper by Dr. Collyer, or at least the more relevant parts of the same. The article is reprinted from the *Anthropological Review*, Lond., 1867, V, 331–339.

Professor Busk, whom I had not the pleasure of knowing at the time, pronounced the "coprolite jaw" in the most summary manner to be "the jaw of some old woman, perhaps from some Roman burial ground" and also said that the "Abbeville jaw" had been proved to be a deception practised by the workmen on M. Boucher de Perthes. Everyone present at this juncture looked on me as an imposter or a fool for having the rank temerity to have dared to foster on such authorities and experts "my jaw" without prestige or unheralded by fame. I, however, said mentally this "old woman's jaw" shall "be heard;" but to vindicate the facts at that moment was out of the question. The tide had turned against me. I enjoyed a private laugh at the perversity of even the highest apostles of the science of geology, hitherto proscribed by the bigotted and intolerant. I was conscious of the genuineness of the "coprolite jaw."

Next morning Professor Huxley called at my house and pronounced the "coprolite jaw" to be a "most extraordinary specimen." I gave it to him so that a careful examination should be made, and received the following:

ROYAL SCHOOL OF MINES, JERMYN STREET, May 2, 1863

My dear Sir: My friend Mr. Busk has taken your remarkable specimen in hand, and I will ask him to inform you as to the conclusions to which he may arrive. No doubt, as I stated when you were so good as to show me the jaw, it has some peculiar characters, but they do not appear to me in themselves adequate to lead me to ascribe the bone to an extinct or aberrant race of mankind, and the condition of the bone is not such as I should expect a crag fossil to be.

I am, dear Sir, faithfully yours,
Dr. COLLYER. T. H. HUXLEY.

The "Abbeville jaw" controversy enlisted at this moment all the most eminent anthropologists of Europe. The principal disputants were in England, Messrs. Hugh Falconer, Busk, Prestwich and Evans; in France, MM. Quatrefages, Delesse, Desnoyers, Lartet, Gaudry, Lyman, Pictet and Boucher de Perthes. Messrs. Prestwich and Evans undertook to show that the flint implements were of modern fabrication. Messrs. Falconer and Busk, that the "Abbeville jaw" contained so large a proportion of animal matter as to pronounce the bone to be comparatively modern when compared with *the drift* with which it was alleged to have been found.

The "coprolite Jaw" was considered, both by Drs. Falconer and Busk, to be of sufficient importance to be taken by them to Paris, so as to show the French savans that a human jaw favorably situated could be infiltrated with a metallic substance; and in the reprint of a pamphlet from the *Natural History Review*, July, 1863:

"An account of the proceedings of the late Conference held in France to inquire into the circumstances attendant on the asserted discovery of a human jaw in the gravel at Moulin Quignon near Abbeville, with notes by H. Falconer, M.D.; George Busk, F.R.S.; W. B. Carpenter, M.D., Vice President of the Royal Society."

At note 37, in referring to the "coprolite jaw" I find these words:

"The specimen is a *very remarkable lower jaw of a human subject* now belonging to Dr. Robert H. Collyer. It is reputed to have been found in the gravel heap of a coprolite pit near Ipswitch; although retaining a portion of its gelatine, it is infiltrated through and through with iron. The Haversian cords are filled with red oxide, and a section of the fang shows that the ivory is partly infiltrated with the same metal. This specimen proves that the human jaw, if favourably placed, is equally susceptible of impregnation with metallic matter as the bones of any other mammal.

(Signed) H. FALCONER,
G. BUSK."

The term fossil has been used to designate a total conversion of a substance into mineral matter. Now, it is exactly in the correct use of this word that the whole question rests. I have in my possession the bone of a deer which was found in the diluvium on the bare rock, twenty-three feet below the surface, with the bones of the mastodon, but the presence of gelatine is at once discovered on submitting a portion of the bone to the action of fire; it is therefore not an infallible test as to the presumed age of a bone that it contains or not a portion of its gelatine.

It now appears that the preservation of the gelatine itself, or its destruction, depends in a great measure in accordance with the earthy or metallic matter with which the bone happens to be in contact. I have found portions of the same bone perfectly fossilized, whilst other parts indicated the presence of gelatine. It is now admitted, as the result of experiment, that bones of recent animals introduced into old deposits, may assume in a comparatively short time the conditions of the bone of extinct animals; while on the other hand, the undoubted fossil bones of extinct animals may, under certain conditions, present a large amount of animal matter. In the Museum of Natural History, Philadelphia, the bones of the megalonyx and the extinct peccary remain in a condition nearly unchanged. Very little of the gelatine has been lost not a particle of the mineral matter added.

To revert to the "coprolite jaw," it was found under circumstances which do not admit of a doubt, but no artificial means could have been employed so as to cause the permeation of the oxide of iron; besides the other peculiarities of the jaw itself all go to prove, most conclusively to my mind that it belonged to a prehistoric human being, whose head was swallowed by a huge carnivore, and the jaw was excremented with other matters by the ducts of digestion.

The coprolites are unquestionably the excrementary deposition of animals who lived on sharks and whales, as we discover immense quantities of the teeth of the former and the bones of the ear of the latter, besides undigested bones of fish are discovered in many of the coprolites.

The "old woman's jaw" has had her revenge.

With true philosophic spirit, and consistent with the high character of a gentleman in the strictest sense, Professor Busk sent me the following:

15, Harley Street, August 19th, 1863

My dear Sir: I have received the jaw from Dr. Falconer, and now forward it to you with many thanks for the liberal use you have allowed us to make of it. I hope you will not consider that it has been much injured by the rough treatment we have submitted it to. In all essential respects it is much as it was, and it has been a great satisfaction to be able to compare its interior as well as exterior with other bones. Having thus had an opportunity of fully examining the bone, I have considerably modified the opinion I hastily expressed at the Ethnological Society. That is to say, it is *very different* from an ordinary churchyard bone, though of course, without any relation as regards age with the fossil bones of the coprolite beds; it is of *very great* antiquity, and it is peculiarly remarkable for the great amount of iron it contains, though still retaining about 8 per cent of animal matter. On the whole, therefore, though not of the portentous antiquity it would have claimed had it been contemporary of *Elephas meridionalis*, the "coprolite jaw" fairly claims a considerable age, and I, for one, am much obliged to you for having brought it under notice, and for the liberal way in which you have allowed to it be examined.

Believe me, very truly,

R. H. Collyer, Esq., M.D. George Busk.

Nothing more could be expected from Professor Busk; when he says the coprolite jaw is of very great antiquity, he admits the whole question.

I have now the pleasure to add a letter from Mr. John Taylor which completes the history of this really extraordinary specimen:—

97 Fore Street, Ipswich, November 13, 1866

Dear Doctor: I was very agreeably surprised to hear from you this morning. If I had known you were residing in Boulogne-sur-Mer, and had possession of "the jaw," I would have called upon you on my way to the Pyrenees last year, in order to have another good look at the bone, which certainly must be of the same age as the coprolite in which it was found.

The history of the matter, so far as I know, is very short.

From what I could learn at the time, from the agricultural labourer of whom I bought it, it came from the coprolite pit on the farm of Mr. Laws at Foxhall, about four miles from Ipswich and was thrown out at Mr. Packard's manure factory with the coprolite from a cart or tumbril, and from thence was brought to me to secure a glass of beer. I had possession of it for near three months, when Sir Thos. Beaver (whose son was then living with me) called on me, and seeing that he exhibited great interest in the inquiry as to the antiquity of the jaw, I had the pleasure of presenting him with it.

There is no doubt the bone was obtained at some depth[1] as I know the pit had been open for a considerable time when it was found.

Having given you all the information I possess, I shall be anxious to hear the result of the investigation.

The account of the "Abbeville jaw" appeared in the *Times* and I suppose yours of this jaw will also.

Yours very truly

Dr. Collyer J. Taylor.

It will be observed that Foxhall, where the "coprolite jaw" was found, is a few miles from Kyson, where Sir C. Lyell says the first example of a fossil quadrumanous animal was discovered in Great Britain, namely the teeth and part of the jaw of a monkey, of the genus Macacus. The eocene strata in the vicinity of Woodbridge and Ipswich are exceedingly rich in animal remains of a prehistoric condition of the world: I see no reason whatever for doubting the antiquity of the "coprolite jaw."

These facts should at least make the sceptical pause, on the probability that man may be no exception to the rest of creation.

CRITICAL NOTES ON THE FOXHALL JAW

A. HRDLIČKA

The Foxhall jaw has never been accepted by anthropologists as representing a form of early man, and it would not even be known of by the present generation had it not been lately recalled by Keith[1], Moir[2] and Osborn.[3]

[1] I visited the coprolite pit in 1855, immediately after it was found, and ascertained that it had been worked for over a year. The place from which "the jaw" in all probability came, was sixteen feet below the surface.

[1] Keith (Arthur)—The Antiquity of Man. 8°m Lond., 1915, 200, 224.

[2] Moir (J. Reid)—Further Discoveries of Humanly-Fashioned Flints in and beneath the Red Clay of Suffolk. Publ. *Prehist. Soc. East Anglia*, 1920–21; repr. 42 pp.

[3] Osborn (H. F.)—The Pliocene Man of Foxhall in East Anglia. *Nat. Hist.*, 1921, No. 6, 567–9.

Keith in commenting on the specimen is brief and noncommittal (p. 224): "In a former chapter" he writes "reference was made to a lower jaw found at Foxhall, which lies a few miles to the east of Ipswich. The deposit from which the mandible is believed to have come is formed of mid-glacial sands, a stratum of which is to be seen under the boulder clay at Bolton and Laughlin's pit. As already said, the evidence in favor of the antiquity of this specimen is only presumptive."

Mr. Moir, as may be seen from his good paper in the preceding pages, while acknowledging himself unable definitely to claim a great antiquity for the specimen nevertheless shows an inclination in that direction.

Osborn in his article on "The Pliocene Man of Foxhall" etc. (published early in 1922) is duly careful, though evidently not convinced that the jaw if found might not prove of much value in connection with man's antiquity. He says: "It would be hazardous for the writer even to express an opinion as to whether this jaw is of Pliocene age. The imperfect figure reproduced on the opposite page shows it to be different from the two most ancient jaws we know, namely those of the Piltdown and Heidelberg men, for it apparently had a prominent chin. It is possible that the mineralization of the jaw was due to deep intrusive burial. To settle these questions the jaw *must be traced and found.* Even if the jaw proves to belong to *Homo sapiens*, Dr. Collyer's paper has suddenly become a classic because it has led to the long awaited discovery of Tertiary man which may now be described."

In view of the growing interest in the Foxhall and Ipswich as well as the not far distant Cromer finds, relating to early man, it is well to ask just what in the scientific light of to-day the Foxhall jaw represents.

There are to be considered the circumstances of the find, the state of preservation of the specimen and its morphology.

The circumstances of the find are very uncertain. They are such that no scientific man would probably care to assume the responsibility of giving them great weight, one way or the other. The bone was not seen in place; it was found by a laborer and that only after being "thrown out at Mr. Packard's manure factory with the coprolite from a cart or tumbril;" and apparently no effort was made by anyone until long after its discovery to corroborate and extend such meagre information as was given with the specimen. The only evidence that the jaw may have lain in the geologically old coprolite layer was its ferruginous mineralization, in which it resembled the animal bones from that layer; but this is evidence of a circumstantial and not very strong nature.

The jaw was in good state of conservation, while all the animal bones recovered later from the layer from which it was believed to have come were so fragmentary as to be beyond the possibility of identification. Mr. Moir very properly calls attention to this enigma. Dr. Collyer, it was seen, offered a somewhat fantastic explanation.

The bone was considerably mineralized, infiltrated with oxide of iron. Such and other forms of "fossilization" or petrifaction of a bone carry generally a deluding flavor of antiquity. Yet they may mean but little, as shown so often in connection with American skeletal remains from Florida, Argentina and other regions.[4] Mineralization of a bone is well known to be a geophysical and chemical process which has more direct relation to the conditions to which a bone is subjected than to time; and similarity of mineralization of two bones, even in the same earthly layer, is not a proof of their contemporaneity but merely an evidence of like results produced under like conditions. The mineralization of the Foxhall jaw, therefore, is no safe criterion of its antiquity.

The Foxhall jaw contained still about 8 per cent (by weight doubtless) of organic matter. A dry fresh human bone has a little over 30 per cent of same. But a bone buried in bacteria-containing stratum loses its organic contents more or less rapidly. The Foxhall jaw was considerably infiltrated with iron and to that extent heavier. Discounting the iron, the true proportion of animal matter to bone must have been materially higher than 8 per cent. And such a proportion of organic matter would normally mean either but moderate antiquity or unusual conditions of inclosure. Possibly a rapid interstitial deposition of the iron may in such a case be influential. The animal bones of the deposit from which the jaw is supposed to have come had less, nevertheless also quite a good deal of organic matter. There is evidently little of anything decisive here, but the indications appear to speak rather against than for a great antiquity of the human bone.

The morphological features of the specimen as illustrated by Dr. Collyer are plain enough, however, to permit definite conclusions.

The first question naturally concerns the size of the specimen. This is nowhere stated and no measurements are given, with one important exception. Dr. Collyer mentions, it will be recalled, that "the condyloid processes are 1½ inches distant from the alae." Under "alae" he cannot mean anything else than the coronoid processes; and if we now turn to the published figure it is found that the distance from the tip of the coronoid to the uppermost point of the condyloid process is precisely 1½ inches, which shows that the illustration gives the jaw in its true size. But if this is so then this jaw, in all its dimensions, falls entirely within the range of recent lower jaws of white man, and at the same time differs radically from all known human jaws of geological antiquity. The form of the bone sustains further this conclusion.

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[4] Bull's 33, 52 and 66, Bureau of American Ethnology.

With more ample comparative material at hand the jaw may with much probability be identified as that of an elderly male. Its original identification as female was doubtless influenced by its rather wide angle, but such an angle is found now and then in recent males. The development of the condyle, that of the ascending ramus, the strength of the chin and the height of the horizontal branch, all speak for a male.

The dimensions of the jaw, as far as they may be measured from the illustration, are: Horizontal length (most prominent point of chin to most posterior point on the angle), 8.75 cm.; minimum breadth of ascending ramus, 3.1; height of ascending ramus, approximately 5.7; height at symphysis (alveolar process damaged) approximately 3.5; alveolar length (from anterior edge of the ascending ramus to furthest point on the alveolar process forward) 5.25 cm. All these are measurements easily comparable with those of an ordinary white male jaw of historic times including the present. It may be safely assumed that there is no larger collection of modern skeletal material in which a recent white male jaw of similar dimensions could not be found, and it would not be a specimen of exceptional size.

The most important of the above measurements is that of the alveolar process. This process in the Foxhall jaw shows a reduction which finds no parallel in the jaws of man of geological antiquity. It is a condition that has followed a reduction in the size of the teeth, which is a late evolutionary character in man. The moderate size of the teeth is well seen in the illustration and the prominence of the chin is a further witness to the shortening of the dental arch. With such arches and jaw the Foxhall male could only have had an orthognathic face like the average white man of to-day and a face of ordinary present-day dimensions. To connect such a face with a man of any great geological antiquity without overwhelming proofs for such a conclusion, will be admitted, I think, as quite impossible.

Taking into consideration the uncertainties regarding the circumstances of the discovery; the good preservation of the specimen in a stratum where all animal bones were reduced to unidentifiable fragments; the considerable amount of animal material which the jaw retained; its form which showed nothing whatever primitive; and above all its measurements which all fit among those of ordinary male jaws of recent white man, it may well be asked what remains as a basis on which the Foxhall jaw could receive any further consideration in connection with older Quaternary, not to say Tertiary, man.

Iconoclasm in science is not a pleasant role; it is a happier lot to be able to sustain; but if progress in anthropology is to be furthered, the mass of our data, more particularly the fundamental data that relate to man's origin and antiquity, must be cleansed of the errors and ambiguities with which in course of time they have become encumbered.

THE VARIABILITY OF SKULL CAPACITY[1]

JOHN RICE MINER

Skull capacity and brain weight are as Pearl[2] has shown, more variable than linear skull characters such as length, breadth and height. This greater variability does not necessarily imply less stringent selection of capacity and brain weight, but may be accounted for on geometrical grounds, capacity being a three dimensional character and brain weight closely related to it. Lee[3] has shown that there is a correlation of 0.7 to 0.8 between skull capacity and the product of skull length, breadth and height. Now from Tocher's[4] formulae for the mean and standard deviation of a triple product it follows that if

v_L = standard deviation of skull length / mean skull length,
r_{LB} = correlation of skull length and skull breadth,

and similarly for v_B, v_H, r_{LH}, r_{BH}, the coefficient of variation of product will be

$$V_P = \frac{100\,[v^2_L + v^2_B + v^2_H + 2r_{LH}\,v_L\,v_H + 2r_{LB}\,v_L\,v_B + 2r_{BH}\,v_B\,v_H]^{\frac{1}{2}}}{1 + r_{LH}\,v_L\,v_H + r_{LB}\,v_L\,v_B + r_{BH}\,v_B\,v_H}$$

V_P is thus a measure of the variation in skull capacity which would follow if the capacity were exactly determined by the product of length, breadth and height. In Table I this is compared with V_C, the observed coefficient of variation of skull capacity, for nine series of skulls. In every case V_P is close to V_C and in some cases is slightly larger. We may therefore conclude that the greater variability of skull capacity as compared with length, breadth or height may be accounted for by its three dimensional nature. The variabilities of visceral weights and body weight, on the other hand (v. Pearl, *loc. cit.*, and Greenwood and Brown, *Biometrika*, vol. 9, pp. 474, 477, 481) are in general of a distinctly higher order.

Another point worthy of some note is the greater constancy of the variabilities as compared with the correlations in passing from race to race.

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[1] Papers from the Department of Biometry and Vital Statistics, School of Hygiene and Public Health, the Johns Hopkins University, No. 109.

[2] *Biometrika*, IV, 31, 1905–1906.

[3] *Phil. Trans.*, vol. 196A, p. 237, 1901.

[4] *Biometrika*, IV, 321, 1905–1906.

TABLE 1

Comparing V_p and V_c

Population	v_L	v_B	v_H	r_{LB}	r_{LB}	r_{BH}	v_P	v_C
Aino♂*	.0319	.0276	.0367	.501	.432	.345	7.58	6.88
Aino♀*	.0308	.0268	.0317	.349	.377	.178	6.53	6.86
German♂*	.0337	.0389	.0447	−.097	.286	.071	7.31	7.77
German♀*	.0357	.0339	.0391	.314	.488	.276	8.07	8.13
Naqada♂†	.0317	.0329	.0398	.489	.344	.273	7.95	7.72
Naqada♀†	.0314	.0345	.0366	.283	.143	.119	6.91	6.92
Whitechapel♂‡	.0331	.0375	.0421	.255	.240	.233	7.94	8.28
Whitechapel♀‡	.0345	.0354	.0396	.425	.350	.340	8.34	8.68
Moorfields♀§	.0328	.0384	.0382	.239	.619	.293	8.37	8.27

*Lee, *Phil. Trans.*, vol. 196A, pp. 230, 231, 1901.

†Fawcett, *Biometrika*, vol. 1, pp. 438, 455, 1901–1902.

‡Macdonell, *ibid.*, vol. 3, pp. 222, 232, 1904.

§Macdonell, *ibid.*, vol. 5, pp. 93, 103, 1906–1907.

THE LIFE CYCLES OF HAIR IN SELECTED REGIONS OF THE BODY[1]

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INTRODUCTION

In order to study successfully irregularities of hair growth, it is desirable to have accurate knowledge of what may be called the normal or average productive behavior of the hair follicle. Satisfactory data of this kind were not found in an extensive search of the literature. The opinion most often expressed is that hair grows at a rate which is determined by dividing the length of the hair by the length of time it is present in the follicle. Bulliard has reported that the growth of hair on the dorsum of the hand comprises two distinct periods: a period of rapid and uniform growth and a period of poise or balance. That there is a cyclic production of hair by the follicle in which each cycle includes first, a period of activity, then a period of quiescence which terminates with the falling out of the hair has been stated by Danforth (unpublished MMS.). To present definite information on the production of hair follicles of several selected regions on the human body is the object of this paper.

This work was done in the laboratory of Professor R. J. Terry to whom I wish to express my sincere thanks for his kindly advice and for his aid in securing subjects for observation and experiment. I appreciate very much the many helpful suggestions of Professor C. H. Danforth and also the interest and assistance of Professor Caswell Grave during the completion of the paper.

METHODS AND MATERIAL

The chief requisite for such a study is an adequate number of definitely identified follicles which may be examined frequently and whose functional activity may be measured by the amount of hair produced. Friedenthal in his directions for studying hair growth suggests the following methods:

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[1] The expenses of this investigation were met in part by the Hypertrichiasis Fund of Washington University.

1. For the stronger hairs put rings (Zeitringe) of the finest platinum wire around the hairs at regular intervals.

2. For finer hairs: (a) put marks (Zeitmarken) on the hairs at regular intervals with the most durable staining fluids, either concentrated alcoholic methyl violet solution or carbol fuchsin solution by means of a very fine brush using the smallest possible amount of stain, (b) cut off single hairs down to the surface of the skin at regular intervals.

In a former experiment the cutting and staining methods were used with some success in ascertaining the rate of growth which was the object sought at the time, but neither of these methods provides for the identification of the follicle after the marked hair has fallen out. If Friedenthal's first suggestion were practicable in other respects, it, too, would fail in this one. In the case of a few hairs, the follicle was made possible of identification by injecting a small amount of the stain under the skin close to the hair. This, after a short time as compared with the life of the hair, disappeared and a more permanent mark was found to be necessary. Various common stains were tried but no one proved to have a lasting effect. The most satisfactory mark and the one finally selected was Higgins' waterproof India Ink, applied as follows: after the surface of the skin had been sterilized with 60% alcohol and allowed to dry the point of a very fine hypodermic needle of a syringe filled with the ink was placed just below the surface of the skin beside the hair. The few particles of carbon which were in the drop of ink on the point of the needle were adequate to leave a permanently visible mark. A similar injection was made on the other side of the hair directly opposite the first one and in such a position as to leave the follicle which it was desired to mark at the mid-point of a straight line between the two permanent black dots. The injections were made at points sufficiently distant from the hair to insure against injury to the follicle. The injections caused no noticeable hyperaemia or other reaction that could be thought to have any effect on the function of the follicle.

The hairs from the marked follicles were measured weekly. The length was determined by laying a white, celluloid strip graduated in millimeters from one end along the hair. It was always held close to the surface of the skin beside the hair. The hair was then applied to the ruler by means of eyebrow tweezers and the point on the ruler reached by the distal tip of the hair was recorded. In the cases of shorter and finer hairs a watchmaker's lens aided in making the determination. Other procedures for measurement, especially variations of a method for passing the free end of the hair into a fine glass tube graduated in millimeters were tried, but no one of them proved as satisfactory as this simple method of direct measurement. The accuracy of this method depends mainly upon the degree of pressure with which the ruler is held against the surface of the skin and the amount of "pull" exerted on the hair in straightening it out against the ruler. In a very short time the habit of exerting a consistent degree of tension is acquired, and since all data were recorded by the writer, variation due to the personal equation was largely eliminated.

The diameter of the hair was determined by the same method as described in an earlier study (Trotter '22).

The subjects which afforded the data fall into a somewhat varied groups. All of them were girls and women between the ages of 13 and 45 years. Both normal and insane subjects were studied. The group of insane was made up of both colored and white institutional patients, all with a diagnosis of either dementia praecox or imbecility. Practically the entire number in this group was under observation for eleven months. The normal group consisted of children in an orphan's home, nurses in a training school and students in a university. Some acted as subjects for as long as nine months while others were accessible for examination during shorter and variable periods. The following table shows the distribution of the subjects according to age, color and mental condition:

Classification of subjects		Age	Number of individuals
Normal	Orphans	13–14	8
	Nurses	19–22	7
	Students	21–25	5
Insane	White	17–20	5
		20–30	8
		30–40	13
		40–45	4
	Colored	17–20	2
		20–30	6
		30–40	16
		40–45	5
Total			79

The regions of the body selected for study and the types of hair on the particular region according to one grouping (Danforth, unpublished MMS.) are shown in the following table:

Region	Type of Hair
1. Pubic	Terminal
2. Axillary	Terminal
3. Proximal part of anterior crural	Transitional

It seemed desirable to compare the activity of the follicles of general body hair with those follicles which produce markedly developed hair at puberty. Consideration for the subjects made it necessary to use regions not likely to be exposed, since the marks are permanent. With these facts in mind the areas listed were chosen for study. Hair of the axilla was studied only in the insane adults. In the normal adults hair of the pubic region was substituted for that of the axilla because of the custom of depilation of axillary hair.

PERIOD OF GROWTH

Although a wide variation in the hair of different individuals exists it was found that the rate of growth on the whole tends to be constant for a particular region. Also the rate of growth was found to show a positive correlation with both the length and diameter of the hair.

In the case of hairs on the legs in the white subjects the average rate of growth increased steadily as age increased. In the 13 and 14 year old group the average rate is 1.42 mm. per week, while in the 40 to 45 year old group it has increased to 1.85 mm. per week. The following table shows the average rate of growth, the number of hairs on which the figures are based, and the number of individuals in the different age groups:

TABLE I

Age	No. of individual	No. of hairs	Average rate of growth per week in mm.
13–14	8	73	1.42
17–20	5	128	1.45
19–22	5	16	1.45
21–25	5	48	1.56
20–30	8	135	1.57
30–40	12	190	1.62
40–45	4	48	1.85

A similar table for the colored subjects shows the same tendency in the rate of growth:

TABLE II

Age	No. of individuals	No. of hairs	Average rate of growth per week in mm.
17–20	2	11	1.28
20–30	6	54	1.34
30–40	16	105	1.38
40–45	5	12	1.40

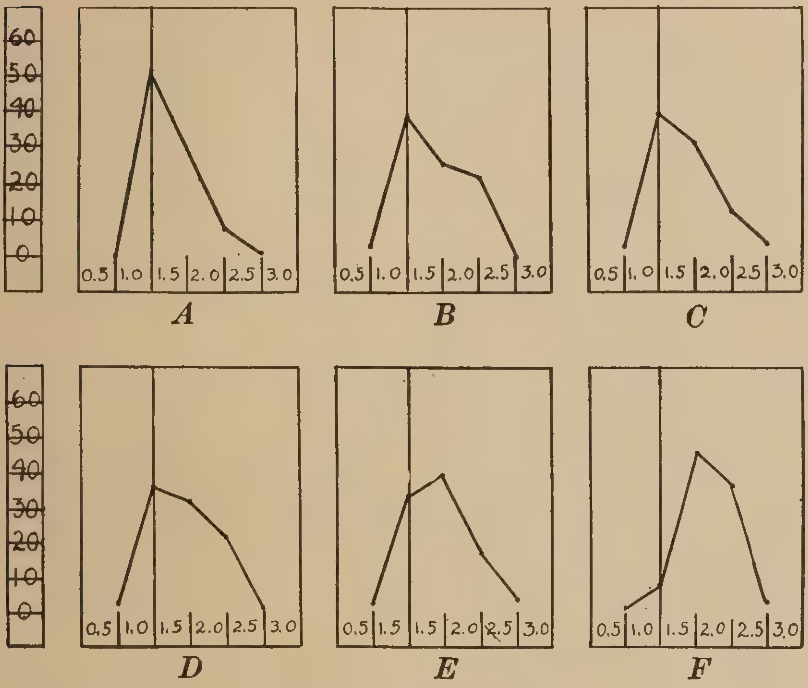

FIGURE 1. Curves to show the mode and range for the rate of growth of hair in mm. on the legs of white women. The abscissae represent the rates of growth in mm. and the ordinates, percentages of the total. A represents data from women between the ages of 13 and 14 years; B, between 17 and 20 years; G, between 21 and 25 years; D, between 20 and 30 years; E, between 30 and 40 years; and F, between 40 and 45 years.

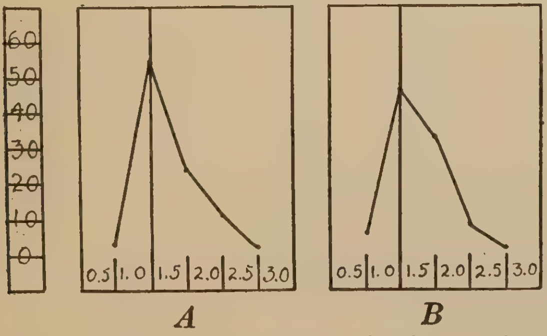

FIGURE 2. Curves to show the mode and range for the rate of growth of hair in mm. on the legs of colored women. The abscissae represent the rates of growth in mm. and the ordinates, percentages of the total. A represents data from women between the ages of 20 and 30 years, and B, between 30 and 40 years.

When the average length and diameter of the hairs studied were determined it was found that they too increased gradually with increase in age which is in accord with results found in an earlier study of the hair of the face (Trotter '22). However, that the age of the subject *per se* determines the rate of growth does not seem to be borne out by these data. For example, hairs the ultimate length of which is less than 12 mm. grow at a slower rate on women between 40 and 45 years of age than do hairs the ultimate length of which is more than 12 mm. on women whose ages are between 20 and 30 years. In other words, while for hairs of a given size the rate of growth increases with age, a small hair on an older woman grows more slowly than a large hair on a younger woman.

The modal rate is from 1 mm. to 1.5 mm. per week for the colored subjects of all ages and for all white subjects under 30 years. The remainder of the white subjects showed the modal rate to be between 1.5 mm. and 2 mm. per week. The range about the mode is shown in figures 1 and 2 for the different age groups. In successive curves the tendency for the crest to move more and more to the right is apparent; that is, in A, B, C and D of figure 1 the mode is between 1 mm. and 1.5 mm., but in B the 1.5 mm. to 2 mm. group has risen higher than it was in A; in C it is higher than in B and in D it is higher than in C. Likewise in E and F although the mode has shifted to the 1.5 mm., to 2 mm. rate the 2 mm. to 2.5 mm. rate has gained very noticeably in F over what it was in E. The same tendency is shown in the colored individuals (figure 2). The mode is between 1 mm. to 1.5 mm. in all the groups and the two groups for which curves have been made show the 1.5 mm. to 2 mm. point to be higher in the older group or that the crest is moving to the right as in figure 1.

In the axillary region of both races and on the pubic region of the few cases examined there was wide variation of the hair of different individuals and also variation of the hair of the different age groups in the rate of growth. However, the following table presenting the average rate of growth of axillary and pubic hair in white subjects shows that there is not a constant increase in rate of growth with advance in age:

TABLE III

Age	Region	No. of diviinduals	No. of hairs	Average rate of growth per week in mm.
17–20	Axillary	5	78	2.20
19–22	Pubic	8	40	2.09
21–25	Pubic	1	9	2.64
20–30	Axillary	8	113	2.42
30–40	Axillary	12	131	2.11
40–45	Axillary	4	48	2.21

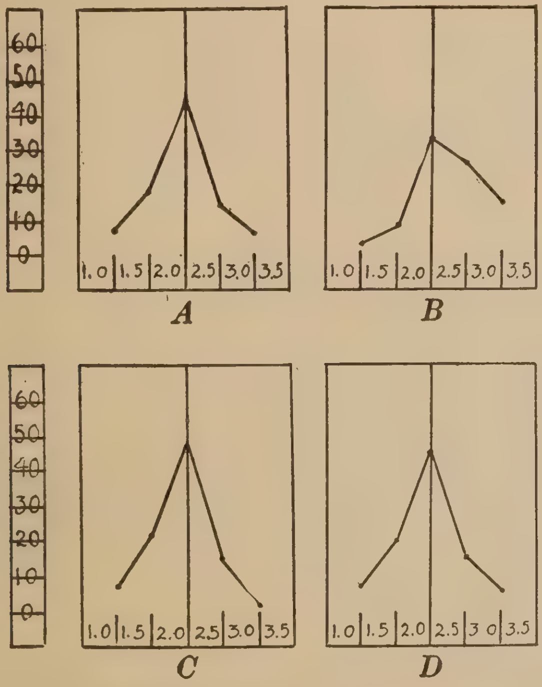

FIGURE 3. Curves to show the mode and range for the rate of growth of hair in mm. in the axillae of white women. The abscissae represent the rates of growth in mm. and the ordinates, percentages of the total. A represents data from women between the ages of 17 and 20 years; B, between 20 and 30 years; C, between 30 and 40 years, and D, between 40 and 45 years.

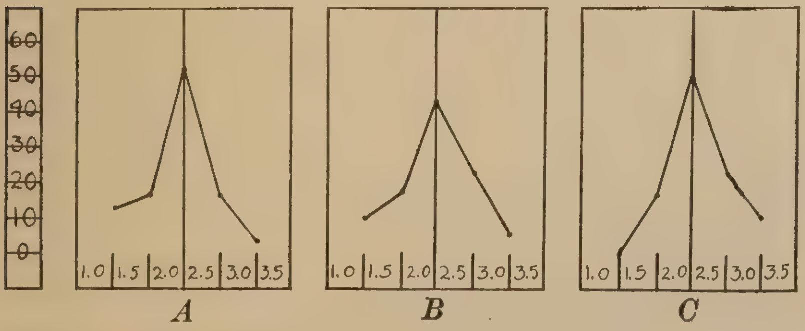

FIGURE 4. Curves to show the mode and range for the growth of hair in mm. in the axillae of colored women. The abscissae represent the rates of growth in mm. and the ordinates, percentages of the total. A represents data from women between the ages of 20 and 30 years; B, between 30 and 40 years; and D, between 40 and 45 years.

The following is a similar table based on the axillary region of the colored subjects:

TABLE IV

Age	No. of individuals	No. of hairs	Average rate of growth per week in mm.
17–20	1	7	2.68
20–30	6	46	2.09
30–40	14	134	2.06
40–45	6	37	2.33

The average length and diameter of the hairs of the axillary and pubic regions were found to differ also from those of the leg in showing a definite increase only when passing from the group under 20 years to the group between 20 and 30 years and remaining relatively constant in the older groups.

The modal rate of growth in every group is between 2 mm. and 2.5 mm. per week. The distributions shown in figures 3 and 4 are more symmetrical about the mode than those of figures 1 and 2.

PERIOD OF QUIESCENCE

All hairs are not in an active growing state at any given moment. This is readily demonstrable by cutting those in a given area close to the skin and noting that only a part of the entire number reappears at once. To illustrate this fact small areas were outlined on four subjects, the number of hairs enclosed was carefully determined and they were then cut off to the level of the skin. After a period of two weeks the areas were closely examined and 45% of the entire number of hairs (230) were found to have grown to an appreciable extent. The other 55% had remained unchanged, showing that the follicles in these cases were at this time in a resting phase.

In every group, in both races and in all the regions studied the duration of the resting period of a large proportion of the hairs corresponded very closely to the length of the growth period. In all cases the percentage of the group, the resting period of which approximated the growth period, was well over half of the entire number, but the distribution of the remainder seems to be significant. With the hairs of the leg the tendency in the majority of those which varied from the general rule was to remain in a quiescent state for a period considerably longer than the growth period, while in the hairs of the axillary and pubic regions the reverse condition was found—a tendency to a period of rest shorter than of growth. This condition was again noted when the proportion of growing hairs was compared with that of resting ones.

In every group the number of hairs which were in the quiescent state at any one time was more than half of the entire number, but the percentage of the group was markedly greater in hairs of the leg than in those of the axillary and pubic regions. Therefore since hairs on the axillary and pubic regions tend to have a resting period of shorter duration proportionately than hairs on the leg, a lesser number of axillary and pubic hairs are in a resting state at any given moment. There was slight variation in the different age groups. The following table lists the proportion in percentages of resting hairs found at any one time and the proportion of hairs the period of rest of which is as long as, or longer than, the period of growth:

TABLE V

Race	Region	No. of hairs	Per cent of hairs in quiescent state	Per cent of hairs resting as long as or longer than growth period
White	Anterior crural	557	83	88
Colored	Anterior crural	461	82	90
White	Axillary	392	54	57
Colored	Axillary	353	58	60
White	Pubic	34	54	56

In most instances the new hair appeared before the old one had fallen out. However, the appearance of a new hair from a follicle containing an old one which had been for some time in a quiescent state, was indicative of the time when the old one would fall, or be pushed out. This period was always short, usually not more than a week in length. The new hair would then continue to grow at the rate of its predecessor, and repeat the cycle which was representative of that particular follicle.

DISCUSSION

If insanity has a direct bearing on hair growth one would expect to find evidence of it in a study of this kind. The impression seems to be general that excessive growths of hair are most often noted when walking through "asylum wards." The more recent comparative studies bearing on this point seem to show conclusively that such impressions have no foundation in fact for when an adequate number of sane and insane subjects is compared with reference to quantity of excess hair no difference is found. The results of the present study seem to bear out this conclusion for although the number of insane subjects under observation was greatly in excess of normal subjects, nevertheless no indication of increased hairiness has been detected. In a series of data arranged according to age groups, the results from normal individuals form a consecutive series with those from insane individuals.

There is a possibility that some forms of insanity other than dementia praecox and imbecility do have a direct influence on the growth of hair but in so far as dementia praecox and imbecility are concerned no effect whatever in the regions examined was observed.

Hair of the axillary and pubic regions represents a more or less special type both structurally and in time of appearance. It differs from hair of the anterior crural region and also of various regions of the face in that it does not show an increased rate of growth and size with advancing age. The relative duration of growth and rest periods is not the same as that found in hair of the anterior crural region. It is possible that those differences do not characterize two entirely different types of hair but that, with the study of hair of other regions of the body, data might be acquired which would permit an arrangement of hairs in a regularly graduated series based on slight variations of the several properties already discussed. However, with the data at hand it is probably more logical to conclude that the hair of the axillary and pubic regions belongs to a special category. The fact that it does not appear until relatively late and then in its ultimate condition with no increase in rate of growth or size is interesting and perhaps of significance from the point of view of ontogeny.

Just what tendency, or change in tendency, a particular hair follicle may manifest with advance in age is a significant query. A study extending over a much longer time than has been covered by this study would be necessary to settle this point conclusively. An increase in rate of growth, length and thickness of the hair takes place with advance in age but these changes are not brought about by age alone. An interdependence and correlation of many factors is very probably necessary for the normal functioning of the follicle. This would seem to be true because of the relation already indicated between the size of the hair and the periods of activity and rest in the follicle together with the variation of these factors in different parts of the body. In short, each follicle has a considerable degree of autonomy in its development and function, but its activity is in some measure regulated by factors external to itself.

CONCLUSIONS

Data derived from the insane do not bear out the prevalent impression that disturbances of the nervous system result in more abundant hair growth, at least so far as dementia praecox and imbecility are concerned.

The growth period and the quiescent period of the follicle are of approximately equal length.

The cycles of individual follicles are of relatively constant duration.

Follicles in the pubic and axillary regions are more active than on the leg both as to rate of hair production and as to relative duration of activity.

Hairs of the leg show a steady increase in size and in rate of growth with advance in age. A similar increase in rate of growth was not found in hairs of the pubic and axillary regions.

The hairs of the colored race show the same general tendency as hairs of the white race in periods of growth and quiescence, but age changes and other deviations are less marked.

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SOME OBSERVATIONS ON THE GROWTH OF COLORED BOYS

MELVILLE J. HERSKOVITS

The following data were secured in the course of an investigation into the general problem of Variability under Racial Crossing, and were obtained, together with other numerous measurements not treated here, from the children of Public School 89, Manhattan, New York City.[1] This school is situated in the heart of the Negro district of Harlem, and represents a population which is highly mixed, from a racial point of view. It is exclusively a boys' school in the upper grades, and the group from which it draws its pupils is best described, from an economic standpoint, as near the poverty-line. The significance of this will be discussed later.

The two measurements, the data of which are presented below, are height and weight. All measurements were taken by the writer. Height was measured to the nearest centimeter on a wooden measuring-rod, which had a projecting movable arm, and was obtained with shoes not removed, due to practical necessities. The height of the heel of each boy, however, was taken with the sliding caliper to the nearest millimeter, and, in the course of the investigation fifty-five boys, selected at random, were asked to remove their shoes, when the measurements were recorded first without shoes, and later in the usual way. The average error due to incorrect estimation of the height of the heel is only .4 centimeter, and since all measurements were taken to the nearest centimeter, and all net heights (after deduction for the heel) tabulated the same way it can be seen that this would make little difference in the final result. Weight was taken on an ordinary scale, which was balanced every morning when measuring was commenced to insure accuracy. The weight of the boys was taken without coats, sweaters, or overcoats, but with shoes, and are presented below as recorded.[2] Age was checked with the school record, calculated in years, months, and days, and tabulated to the nearest half-year.

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[1] The thanks of the writer are due to Dr. Jacob M. Ross, Principal of Public School 89, and his staff of teachers, for their cordial cooperation and forbearance in this research. Their helpfulness during the taking of these measurements constitute no small element in making these results possible.

[2] Comparability of weight results of different investigators of children is exceedingly difficult, due to the general negligence in the matter of specifying deductions made for clothing, if any. Therefore, the data are here presented without reduction.

In Table I are presented the number of cases for each age, the mean and standard deviation of the mean, the standard deviation of the array, and the increment for each year over the preceding year for the height of the Colored children measured in the course of this study, and comparative data presented by Boas for 45,151 White children of

TABLE I

Height of Boys (in centimeter).

Age	M J H 1,006 Colored				F Boas 45,151 White				Greenwood 235 Colored		Hrdlička 110 Colored	
	N	M	σ	Δ	N	M	σ	Δ	N	M	N	M
5												
5½	13	112.3 ±1.1	±3.8	—	1535	105.90	±4.80	—				
6											5	110.1
6½	38	115.7 ±.85	±5.2	3.4	3975	111.58	±4.92	5.68				
7											5	114.7
7½	86	120.9 ±.65	±5.9	5.2	5379	116.83	±5.22	5.25				
8											13	119.6
8½	108	126.7 ±.52	±5.5	5.8	5633	122.04	±5.53	5.21				
9											25	125.1
9½	106	131.1 ±.59	±6.1	4.4	5531	126.91	±5.66	4.87				
10									28	129.5	12	127.1
10½	103	135.7 ±.65	±6.6	4.6	5151	131.78	±5.90	4.87				
11									36	135.3	12	136.0
11½	114	140.5 ±.51	±5.5	4.8	4759	136.20	±6.32	4.42				
12									44	135.4	10	138.1
12½	103	144.3 ±.74	±7.5	3.8	4205	140.74	±6.80	4.54				
13									51	142.3	13	139.2
13½	116	148.9 ±.75	±8.1	4.6	3573	146.00	±7.71	5.26				
14									29	149.4	7	150.5
14½	105	156.3 ±.73	±7.6	7.4	2518	152.39	±8.66	6.39				
15									33	154.9	6	145.5
15½	75	161.8 ±.81	±7.1	5.5	1481	159.72	±8.87	7.33				
16									9	163.6	2	150.0
16½	25	161.8 ±1.74	±8.7	0.0	753	164.90	±7.75	5.18				
17									5	165.1		
17½	12	164.1 ±1.31	±4.6	2.3	429	168.91	±7.23	4.01				
18												
18½	2	162.0	—	—	229	171.07	±6.74	2.16				

Boston, Milwaukee, St. Louis, Worcester, Toronto, and Oakland,[3] by Greenwood for 235 Colored children of St. Louis, and by Hrdlička for 110 Colored Orphanage Children.[4] When we compare the data which have been presented in this investigation with these other data which are available, we find that the children measured in the Harlem district of New York are larger, age for age, not only when compared to the few other Negro children whose measurements have been published, but strikingly larger when compared with the large series of White children published by Boas. All this is of significance in the consideration of possible racial differences as brought out in the table. Comparison with measurements of other Negro children are not satisfactory, since for Hrdlička's and Greenwood's data, the conditions differed and, for Greenwood's series the number of children in the series and their social background remain unknown. However, the figures are here presented in the form in which they were available.** The boys in Boas' compilation, however, afford us an excellent cross-section of the total White population. They represent perhaps the largest series available, and from a point of view of economic background and therefore nourishment, give an important representation of the actual mean height. As has been remarked, the children measured by the writer are near the poverty-line, and it is therefore of undoubted significance that the height, age for age, from the 5th year to the 16th, shows a decided advantage on the part of the Colored boys. Whether this is a function of the racial composition of the group one is not prepared to state, for the group is of great heterogeneity. The 1% of White children in Public School 89 were not measured; it is undoubtedly true, however, that the Colored boys represented in this series are of mixed racial heredity in the main. In the course of the research measurements and genealogies obtained from over 125 adults living in Harlem showed only two persons who claimed to be of pure Negro descent. This heterogeneity of the group might be inferred from the large variability which is present in the Colored boys' series, altho it is also seen in the White series. However, there must be considered against the acceptance of the view that this variability is a result of racial mixture, the shortness of the series here presented, and the tremendous variability which must be present in the social background of these children, and which undoubtedly is intimately connected with the growth of the individual children, as we know from studies on children of other racial groups.[5] Again, the fact that there are many of these Colored boys who were born in the South of the United States, in the British West Indies, or in Panama, may also contribute to this large variability. But it must also be remembered that Boas' series represents all sections of the country, that there must be many children who were not born in the cities where they were measured, and that the Oakland children, who are included in the series, were the largest of any city in the country. This question can only be solved by comparison of data from two groups, each racially and environmentally homogeneous.

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[3] F. Boas. The Growth of Toronto Children. Rep. of Comm. of Education, U. S. Bureau of Education, for 1896–98, xxxiv, p. 1555.

[4] J. H. Greenwood, Heights and Weights of Children, Ann. Rep. Public Health Ass'n., vol. xvii (1891) pp. 199-205. Hrdlička, Aleš, Anthropological Investigations on 1,000 White and Colored Children of both Sexes, 47th Ann. Rep., N. Y. Juvenile Ass'n., (1899), pp. 1–86. These tables are also reproduced by Bird T. Baldwin in his helpful monograph, The Physical Growth of Children from Birth to Maturity, Univ. of Iowa Studies in Child Welfare, vol. i (1920–21) No. i, pp. 261 ff.

**Dr. Hrdlička informs me in a recent letter, that "all measurements of height were made with the children barefooted and in their underclothing, with the Broca 'planche anthropométrique' and according to the standards of the French school. . . ." Since the children the data for whom are given in the present research were measured with shoes and the height of the heel deducted, a slight allowance for error on my part should be made in comparing the two series.

The increase in stature from year to year is worthy of notice at this point, when comparison between Boas' series and the present one is made. While there is a shifting from one year to the next in the advantage of increase between the two series, the general trend is very similar, the greatest gain being made by the Colored boys between their 13th and 14th years, by the White between the 14th and 15th. One is somewhat at a loss for a cause to which to ascribe the striking decrease in gain observable in the Colored boys between the 16th and 17th years; the most plausible explanation would probably be that the sample for this year is too small to hold any significance, it numbering only 25 cases.

When we turn to a consideration of the weight of these boys, we are confronted at once with the difficulty, mentioned above, of accounting for the weight of clothing. Many reporters of data do not specify the allowances made, if any, in the compilation of their results, and this makes for added difficulty in making comparisons. Baldwin[6] states that it is his practise to allow 75. kgm. for children under 12 years of age, and 1.1 kgm. for those over, when they have been weighed without shoes, coats, or overcoats. In the instructions for measuring Toronto children, Boas orders weight to be taken in "ordinary indoor costume."[7] Bowditch, who made a study of clothing, allows 8%, but this must account for shoes, coats, and outer clothing.[8] In Table II, no de-

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[5] Franz Boas, The Growth of Children as Influenced by Environmental and Hereditary Conditions, School and Society, vol. xvii (1923), pp. 305–308. Milo Hellman, Nutrition, Growth, and Dentition, Dental Cosmos, January 1923.

[6] Op. cit., p. 27.

TABLE II

Weight for Boys (in pounds).

	M J H 1,000 Colored				Boas and Wissler 2,109 White				Greenwood 235 Colored		Hrdlička 700 Negro & White	
Age	N	M	σ	Δ (increase)	N	M	σ	Δ	N	M	NM	MΔ
5											33.1	—
5½	13	44.2 ±1.1	±4.17	—								
6											39.9	6.8
6½	38	48.0 ±.97	±6.8	5.8	109	45.7	±5.5	—				
7											45.0	5.1
7½	86	51.5 ±.62	±5.6	3.5	202	49.7	±5.9	4.0				
8											47.0	2.0
8½	108	58.5 ±.62	±6.5	7.0	190	54.1	±6.4	4.4				
9											52.9	5.9
9½	106	63.6 ±.76	±7.9	5.1	220	59.4	±7.3	5.3				
10									28	72.7	57.0	4.1
10½	102	69.6 ±1.13	±11.3	6.0	221	65.8	±8.5	6.4				
11									36	78.2	61.7	4.7
11½	113	77.0 ±1.08	±11.5	7.4	210	71.3	±10.3	4.5				
12									44	83.0	70.1	8.4
12½	102	82.0 ±1.43	±14.5	5.0	246	78.4	±12.2	7.1				
13									51	89.0	80.9	10.8
13½	115	93.2 ±1.5	±16.9	11.2	214	86.9	±15.7	8.5				
14									29	93.5	84.0	3.1
14½	104	106.8 ±1.9	±19.6	13.2	203	98.2	±16.5	11.3				
15									33	112.3	85.1	1.1
15½	75	121.1 ±1.8	±16.4	14.7	162	113.8	±20.8	15.6				
16									9	121.1	115.1	30.0
16½	24	116.8 ±2.8	±14.1	4.3	93	122.6	±17.1	8.8				
17									5	130.0	121.9	6.8
17½	12	124.3 ±4.6	±16.1	7.5	39	132.7	±14.9	10.1				
18												
18½	2	106.0	—	—								

[7] Growth of Toronto Children, loc. cit., p. 1542.

[8] Henry I. Bowditch, The Growth of Children. 8th Ann. Rep., Massachusetts State Board of Health (1877), pp. 305–307.

duction has been allowed for clothing, as it was not possible to gather sufficient sets for purposes of weighing. Public School 89 has baths, but only children from the 4th, 5th, and 6th grades use them, and this would not give a sufficient age-range. The clothing (not counting inner coats) of four 10-year boys have an average weight of 3.68 pounds, of 2 11-year boys 4.06, and of three 12-year boys 4.04, but this is not enough to be of any use. However, this series is probably best comparable with Boas' and Wissler's Worcester series[9] where weight was taken with indoor clothing, but without shoes. No comparison will be attempted with Greenwood's or Hrdlička's series of Colored children, as, similarly to the case with height, the details of technique of measurement differed.[10]

In comparison with the White boys of Worcester, we see that the Colored boys maintain the greater weight that might be expected from the greater height they show. The correspondence is very close, even to the fact that they drop behind the White boys during their 16th year. Again, this may be accounted for by the fact that it is at this point that the colored series drops off in number, and that a greater amount of cases might materially alter the result. However, it is not at all safe to make this assumption, and conclusions as to this point must be held in abeyance pending further investigation. It would not be unexpected, however, for White boys to make a gain at about this point, to compensate for their earlier lagging. One comparison with Hrdlička's mixed series will be permitted: it will be noticed that the present group far outweigh, year for year, the Orphanage boys, of whom we are told the Colored number are "slightly smaller" in weight. The discrepancy is so great that even a difference of clothing would not account for the difference. This is what would be expected, if the research by Boas on Jewish children, already cited, may be taken as a criterion. In the gain from one year to the next, the same cyclical aspect is presented by this series as by the one from Worcester, altho the Colored boys lead the others by a year. The noticeable loss in the 16th year is paralleled by a lack of gain in the White series, and similar recovery is made in the 17th year by both groups. In both these ages the greatness of the discrepancy in the Colored series may be attributed safely, perhaps, to the smallness of the numbers. The variability of the Colored series, tho here more regular than was the case with height, again fluctuates when compared

[9] Franz Boas and Clark Wissler, Statistics of Growth, U. S. Bureau of Education, Report of the Commissioner for 1904, Chap. ii, pp. 25–102. The Table is given on p. 26.

[10] See footnote 4, p. 441.

with the Worcester White boys. The fact that the variability is larger here as in the case of height, in the earlier ages, would lead to the further assumption that the greater variability in the earlier years may also be partially accounted for by the fact of earlier development, since the racial composition would be expected to be as diverse in the older as in the younger groups.

Baldwin, in his monograph on the growth of children, has calculated[11] the coefficients of variability for the Iowa children he measured for height and weight. A comparison of the coefficients for the various ages of the respective series will be of interest. Baldwin's data were gathered from a group of 120 children, from 7 to 17 years of age, comprising both sexes, from whom six to ten annual measurements were taken. It is not stated what percentage of the group were boys, so the number of measured boys on which the table is based cannot be calculated, but the use of the coefficients of variability makes direct comparison possible. Here, again, one does not find results which would show any great significance as far as the variability of these two traits is concerned. Allowing for the difference in age at which the midpoints of the intervals

TABLE III

Coefficients of Variability for Iowa White Boys and New York City Colored Boys.

$$C \text{ of } V = \frac{100\,\sigma}{M}$$

	Height		Weight	
Age	N. Y. Colored	Iowa White	N. Y. Colored	Iowa White
6½	4.5		14.1	
7		5.923		17.529
7½	4.8		10.8	
8		4.923		13.776
8½	4.3		11.4	
9		5.669		15.642
9½	4.6		12.4	
10		5.388		15.719
10½	4.8		16.2	
11		5.242		16.247
11½	3.8		14.9	
12		4.929		16.051
12½	5.2		17.6	
13		5.166		16.479
13½	5.4		18.1	
14		5.796		17.752
14½	4.8		18.3	
15		5.273		15.844
15½	4.3		13.5	
16		4.408		12.918
16½	5.3		12.07	
17		3.933		11.500
17½	2.8		13.7	

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[11] Loc. cit., p. 144.

is taken in the two cases, there is seen to result, for both weight and height, a fluctuation in variability which is not to be explained by a racial hypothesis. The coefficients of variability of weight, however, are smaller for the New York Colored series in the earlier years, and larger after the 14th, while no such regularity is observable for those of height.

Thus, we may conclude from the preceding study,

1. That Colored boys grow faster in height and weight to the 16th year than White boys;

2. That the differences in variability between children of these two races, whether expressed in terms of standard deviation or the coefficient of variability, are not sufficient on the strength of these admittedly limited data, at least, to allow of explanation on other grounds than differences in economic background, place of birth, and different social conditions;

3. That Colored boys show the same acceleration in growth characteristic of White boys during adolescence, which, however, occurs approximately one year earlier, even tho the Colored boys come from a poorer economic level than the White boys to whom they are compared;

4. That the data gathered are not sufficient to show conclusively the decrease in yearly gain after the 16th year.

TREPHINED ABORIGINAL SKULLS

From British Columbia and Washington

HARLAN I. SMITH

Two recently discovered specimens extend our knowledge of the distribution of trephined aboriginal skulls and also of a rare narrow type of skull in British Columbia and Washington.

The prehistoric human skulls of Michigan and Ontario, with perforations, probably post mortem,[1] have long been known. Many trephined skulls from the ancient sites of Peru have been deposited in museums, illustrated and described. The present day practice among primitive people has been described. But I do not remember that the trephined human skulls of British Columbia and Washington have been brought to notice, although trephined human skulls were found in the great shell-heap at Eburne, now Marpole, on the north arm of Fraser river in 1898 during my explorations on the Jesup North Pacific Expedition of the American Museum of Natural History, New York.

The distribution of these trephined skulls is now extended to the large shell-heap along the west side of Boundary bay about twenty miles to the south, by the finding of two specimens during 1922. This heap extends on both sides of the international boundary. One of the skulls was of a rare narrow type found in the Eburne shell-heap, the other of a wide type common to the region in both prehistoric and modern times.

These specimens were collected for the Victoria Memorial Museum, Ottawa—the National Museum of Canada—with the kind assistance of my friend, Mr. Ralph L. Roys of Vancouver, in whose company I made several trips from Vancouver to Boundary bay.

The first skull (Fig. 1, Pls. I & II, left Cat. No. XII-B-1555) had been dug out by road builders in the main road cut while securing shell-heap material to use in grading. This road cut is in the part of the heap on the Washington side of the boundary. Part of the face and lower portion of the skull had been broken off and lost when on June 23d I found the skull lying on top of the heap next to the cut where it had been left by the road builders. This skull is decidedly of the rare narrow type. The cut is in the left part of the frontal, nearly circular, about three quarters of an inch in diameter, and tapers inward, that is the circular cut on the outside is larger than on the inside of the skull. About half of the cut edge was freshly broken, probably by the road builders.

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[1] Some of these skulls have apparently been operated upon before death. *Ed.*

The second skull (Fig. 2, Pls. I & II, right Cat. No. XII-B-1556) I found, September 15th, in a cut made in the heap, to get road material, at a point about a hundred yards north of the road cut. This was also to the south of the international boundary. It was in pieces, most of which had their edges freshly broken, apparently by the feet of the road builders. It seems to be of the common wide type of the region. The perforation is in the right parietal, was apparently nearly circular, about one and three quarters of an inch in diameter, and tapers inward strongly, that is the diameter of the circular cut is about half an inch greater on the outside than on the inside. The cut edge of about half of the circumference is missing and here the edge of the bone is freshly broken.

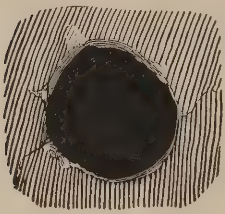

Fig. 1. Trephining in the skull of narrow type.

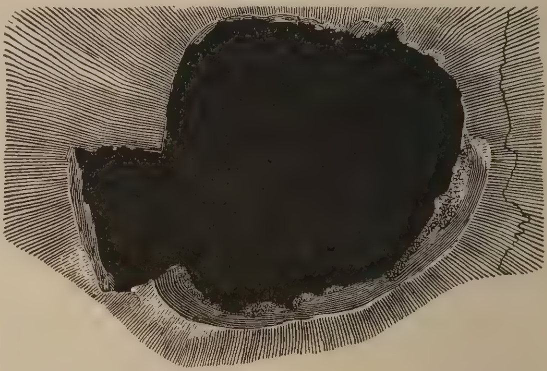

Fig. 2. Trephining in the skull of wide type.

The cutting in both skulls is uneven in outline, that is not an exact circle, showing that it was not made with a compass-like object. It is uneven of surface, both longitudinally and transversely. There are no signs of a growth of bone since the cutting was done, although at least one of the skulls found at Eburne in 1898 plainly showed a considerable growth of bone which had taken place out over the opening after the operation. All the perforated skulls referred to of those found in the Eburne shell-heap, as well as these two specimens from Boundary bay, showed that the perforation was intentional and artificial and cleanly cut, not resulting merely from the thrust of a spear or arrow or from the blow of a club. There is only one hole in each of the perforated skulls of Boundary bay and of Eburne so far as I recall. They are in one side rather than in the centre. Some at least were ante mortem, possibly all.

The two skulls from Boundary bay were submitted to Dr. Aleš Hrdlička, who has kindly supplied me with the following technical report:

"The two skulls submitted to me by Mr. Harlan I. Smith for examination are both defective as to face and base.

"They are both skulls of adult females, one 40–50 years of age, the other probably well over 60. What racial characteristics they present point to the Indian.

"Both of the skulls show occipital flattening; this is especially pronounced in the older female. Without the flattening they would both belong to the Shoshonean—Algonquinian type of skull, though that of the younger female was evidently naturally somewhat shorter than the other. They both have a narrow and rather low forehead.

"There is no sign of any disease or of any injury in life on either skull, but each presents an artificially made cranial aperture.

"In the skull of the younger female (Pls. I & II, right), the aperture is situated in the upper part of the right parietal a short distance behind the coronal suture. Unfortunately the bone has been so badly damaged that only the lower edge of the cut is preserved and even that not in its entirety. The artificial opening was large, measuring slightly over 5 cm. in the antero-posterior diameter. It was evidently oval in shape and the bone was cut out in a fine curve by a very sharp tool which left no irregularities and no secondary cuts about the aperture.

"The most important question in connection with the specimen is whether the artificial opening was made in life or after death and in view of the damaged condition of the specimen this point is not easy to decide. Nevertheless the remaining part of the cut edge of the bone, except where damaged, is nicely bevelled and the bone over this bevelling is so smooth as to be nearly compact, which could only have resulted from a very efficient healing without a trace of inflammation, in life. The case must therefore be put down as one of a trephining on the living, though there is no evidence remaining as to the purpose for which the operation may have been performed.

"The opening in the skull of the older female (Pls. I & II, left) is located on a level with and just back of the left frontal eminence. It is nearly circular, ranging from 18 to 20 mm. in diameter, but there are indications that the lower two-thirds of the edge of the opening has been recently damaged showing a fresh exposure of the bone. The upper third of the opening, while not bevelled and giving at first the impression as if it might have been made *post-mortem*, shows nevertheless on close examination a similar though less marked smoothing and in one spot compacting of the cut surface as observable in the first skull, indicating that the operation here also has probably been performed in life and was followed by slight healing. Here again there is no trace of any inflammatory process and not the slightest redundance of new bone. The case could in fact be readily taken for one of a *post-mortem* cut smoothened by a cord passing through the hole.

"We therefore have here evidently two cases of a native operation on the skull during life. Such operations, common in Peru and Bolivia, so far as known were very rare yet not wholly unknown on the North American continent, The only published cases have been reported by the writer and Lumholtz from northern Mexico[2] in 1897. Gillman, as well known, has described a series of cases of cranial perforation from Michigan[3] but these have always been regarded as *post-mortem* cuts made for the purpose of removing cranial amulets. It has recently been reported to the writer however that one of these skulls appears to show that the operation was performed in life. Two or three isolated instances of supposed trephining have also in more recent years been spoken of from Alaska, New Mexico and one of the middle states, but these specimens have never been properly studied and the nature of the wounds remains uncertain. One such specimen shown to the writer was clearly but a case of healed traumatism."

Aleš Hrdlička

The distribution of the rare narrow type of skull found in the shell-heap at Eburne is extended to the part of the heap at Boundary bay lying across the international boundary in the State of Washington. I do not recall that it was found at Port Hammond. In the Eburne shell-heap there were at least two types of skull. One was narrow and I am not aware that its modern representative has ever been found. The other type was more numerous and seemed to be like the skulls of the Indians of the immediate vicinity. There was nothing to show that one type of skull was of an earlier or later period than the other or that one was of a slave people, the other of a master, as both were found unaccompanied by artifacts, in the same positions, and in the same layers of the heap.

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[2] Trephining in Mexico. By Lumholtz (C.) & A. Hrdlička. (Actually by Hrdlička) *Am. Anthropologist*, X, 1897, 389–396.

[3] On Prehistoric Trephining and Cranial Amulets. By Gillman (H.). *Contrib. N. Amer. Ethnol.*, Wash 1882 also *Trans. Anthrop. Soc. Wash.*, I, 1882, 47–51.

The road builders said a second skull of the wide type had been found by them, near the perforated skull of the narrow type, in the road cut, but that it had just been taken away.

In referring to the shell-heaps of Eburne, Port Hammond, and vicinity

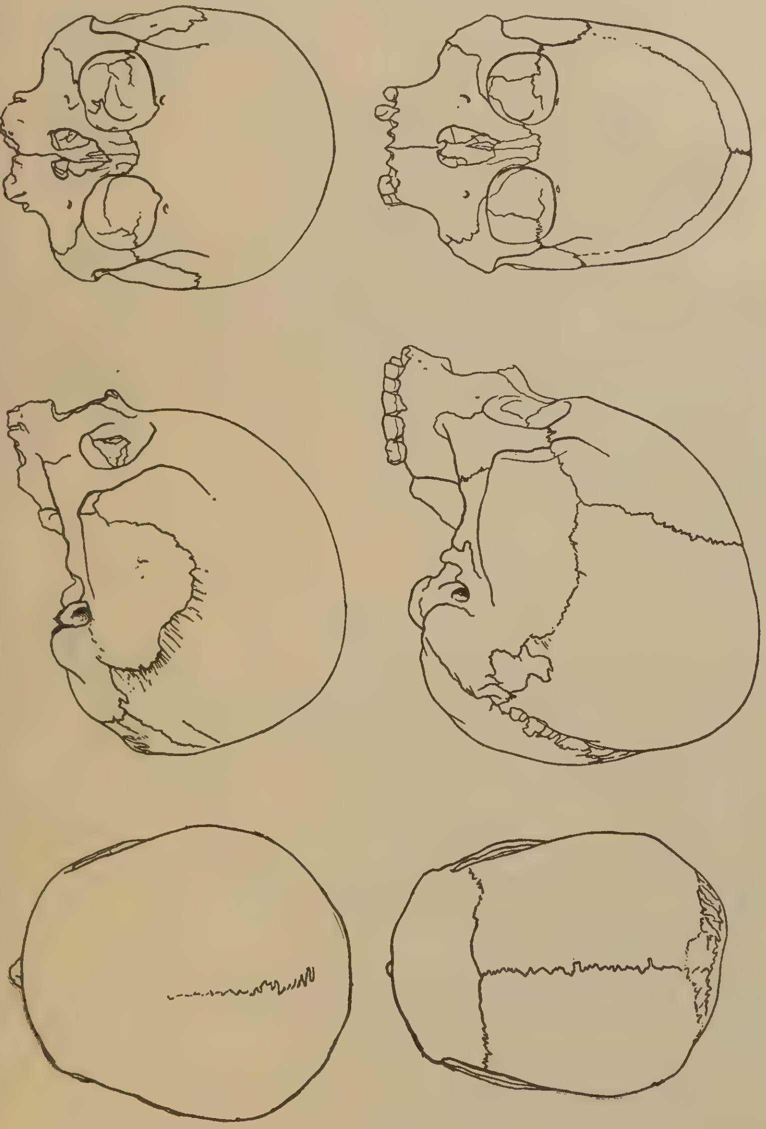

FIG. 3. (99/1544, 99/1770). Types of skulls from shell-mound at Eburne (now Marpole) B. C. Above, three views of narrow type of skull; below, three views of broad type.

in the Fraser valley, I have previously[4] stated that there are, however, some points of difference between the people of the past and those of the present. There are two forms of skulls, one narrow and one broad.

The following measurements of a few selected skulls of the two types will illustrate these conditions:

NARROWER TYPE

Catalogue 99, No.	1816	1544	1752	1813	1812	1810	Average
Sex	Male	Male	Male	Female	Female	Female	
Length of head	186	163	167	171	182	172	173
Breath of head	147	130	138	141	140	134	138
Height of head	146	140	132	136	—	146	140
Minimum width of forehead	98	89	89	95	95	88	92

BROADER TYPE

Catalogue 99, No.	1762	1780	1766	1788	1770	1747	Average[5]
Sex	Male	Male	Male	Male	Female	Female	
Length of head	169	160	158	173	165	158	164
Breadth of head	145	158	157	158	147	153	152
Height of head	135	135	—	142	126	128	142
Minimum width of forehead	(93)	98	104	98	98	99	98

The age of this trephining and the two types of skulls is considerable. The heap at Eburne is known to have existed in 1497 or earlier, as in 1898 we counted over 400 rings of annual growth on a stump standing on the heap. As the outer part of the stump had been burned there must have been more rings, indicating a greater age. Another stump, much larger, was hollow. Consequently its rings could not be counted. There were many large trees and stumps on the heap. The skeletons were below layers continuing unbroken under these stumps. The heap at Port Hammond also had many stumps upon it. How long the heaps had taken to form and how long they had stood before the trees, whose rings we counted on this stump, began to grow, is a matter of speculation.

The Eburne shell-heaps have been described in my monograph on the Shell-heaps of the Lower Fraser, and the one at Boundary bay is mentioned in the one on the Archaeology of the Gulf of Georgia and Puget Sound. Both papers were issued by the Jesup North Pacific Expedition of the American Museum of Natural History. As the bones of all the skeletons were sent to the American Museum of Natural History, further points regarding them can be obtained there, or from the volume in the Memoirs of the Jesup Expedition devoted to the skeletal material, which we may expect shortly.

[4] Pp. 189–190. Shell-heaps of the Lower Fraser River, British Columbia.

[5] Reduced to the proportion of three males and three females.

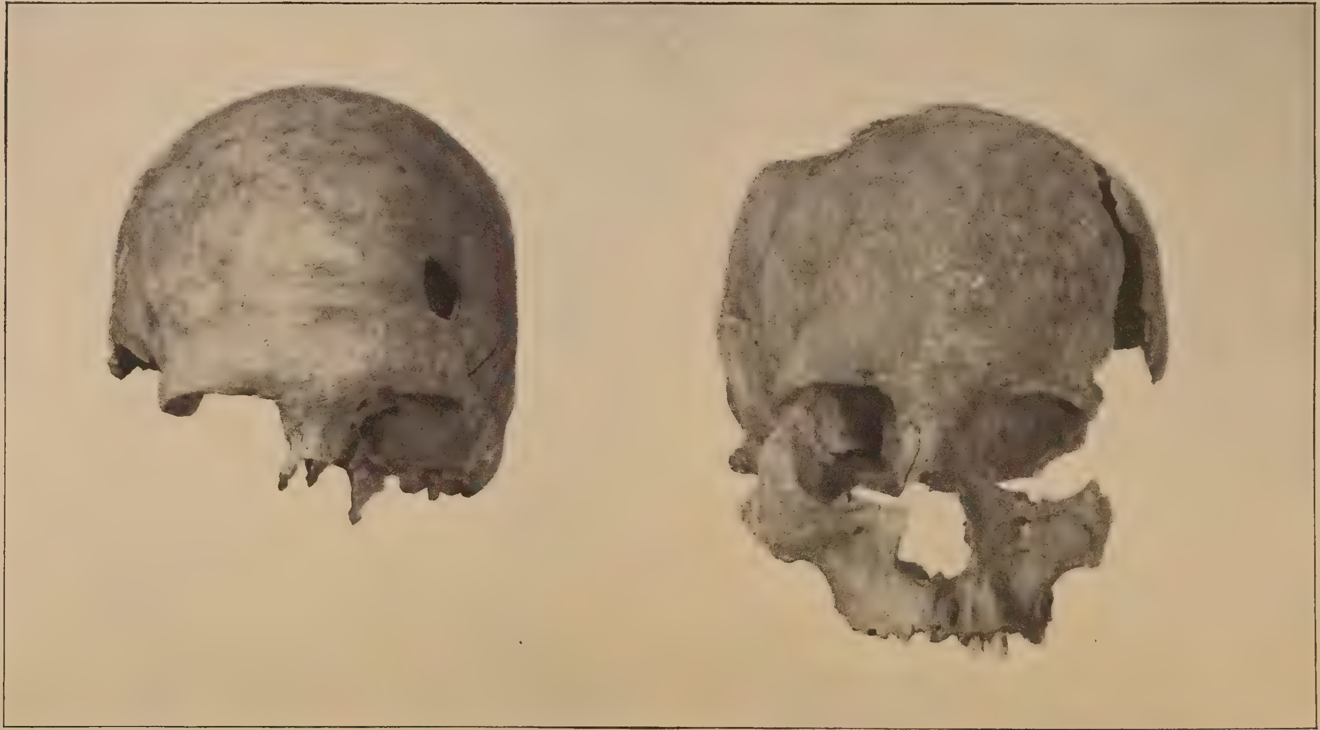

PLATE I—Full face photograph of the two skulls.

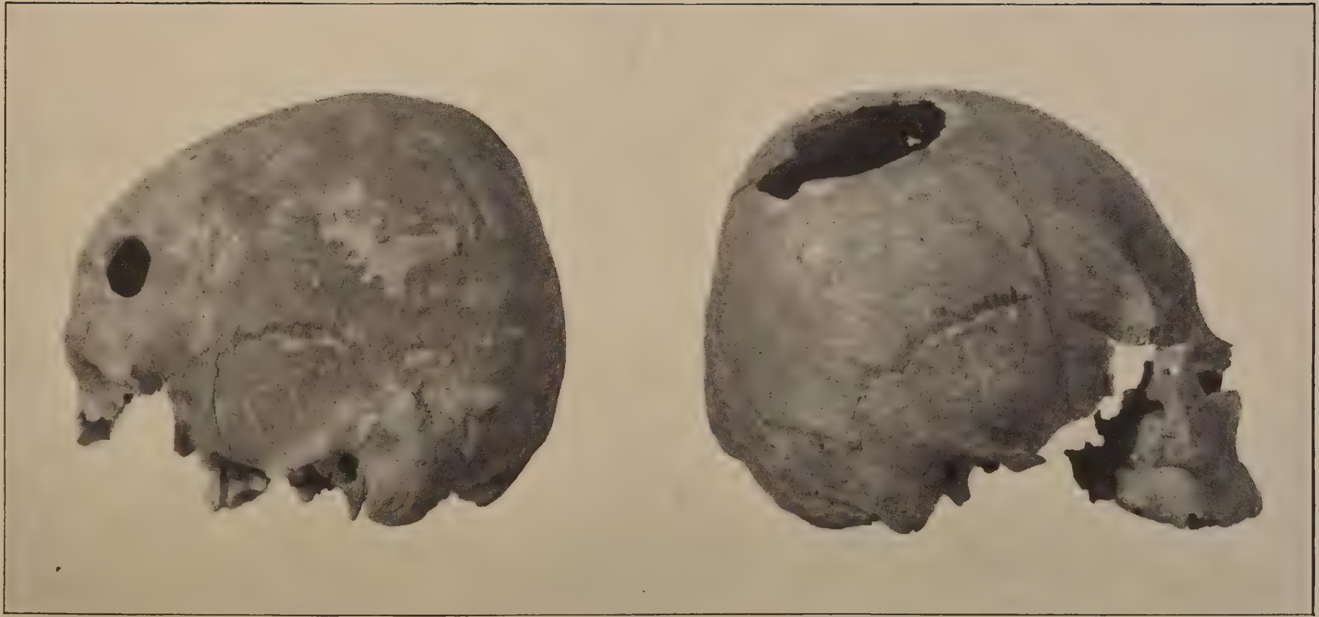

PLATE II—Profile photograph of the two skulls.

LITERATURE

EVOLUTION OF MAN

Der fossile Mensch. Grundzüge einer Paläanthropologie. By Werth (E.)—8°, Berlin, 1921, 1st part, 336 pp.

Only the first part of this new work on fossil man has appeared so far; it contains six of the fifteen planned chapters. Two of these deal aptly with the geology and with the flora and fauna of the glacial epoch, while chapters III to V have for their subject the body remains of fossil man, treated separately for the pre-Neanderthal, Neanderthal, and post-Neanderthal stages. Chapter VI takes up the relations of the diluvial races to each other and to recent mankind. The critical sifting and compiling of the anthropological and anatomical literature on fossil man, together with many original noteworthy contributions to the interpretation of the fossils, render the book of much value. Of the author's manifold interesting conclusions only a few samples can receive special mention: The Mauer jaw should properly be placed closer to the Java man and thus should bear the name of "Pithecanthropus heidelbergensis." A number of features are more highly specialized in Neanderthal man than in the geologically younger races; the former can not, therefore, stand in a direct genetical line with the late diluvial races.

A. H. Schultz.

Fossil Men. Elements of Human Palaeontology. By Boule (Marcelin)—Translated by Jessie Elliot Ritchie and James Ritchie. 8°, Edinburgh, 1923 (Oliver & Boyd), XXVII+504 pp., 250 illustr's.

This welcome and good translation of Professor Boule's already well-known book, which has already reached a second French edition, is from the second of these editions and has been revised by the author as well as brought up to date.

As a brief review of the French publication has been published in the first number of the Journal (p. 139), little needs to be said in addition, except that the English book is printed on very good paper and is altogether a creditable effort which will be much appreciated.

If there is any criticism it applies to the illustrations some of which are by no means the best that could be produced. An especially regrettable instance is the inclusion of the monstrous and wholly artificial view of the Le Moustier skull as originally reconstructed by Klaatsch and Hauser. The skull has since then passed through two scientific reconstructions as the result of which it appears quite different. A number of the other illustrations of crania and skeletal remains of early man are so reduced as to be of little if any use. It is to be hoped that these serious defects will be remedied in further editions.

A critical review of the contents of the book must be reserved for another occasion.

THE EVOLUTION OF MAN. By Elliot Smith (G.)—8°, Oxford University Press, (American Branch), 1924, 159 pp., 19 illustr's. ($2.85).

A book from Dr. Elliot Smith's pen on the Evolution of Man may well be expected to be a production of much interest, notwithstanding the fact that the subject it deals with is becoming rather threadbare from production exceeding the supply of new evidence; and the book may further be expected from Dr. Smith's main researches to give particular attention to mind and the brain. In both lines the expectations are not disappointed, but the author deals also with the cultural and paleontological evidence.

The book embodies three revised addresses by the author delivered by him on diverse occasions and already partly printed. They bear the titles of: The Evolution of Man, Primitive Man, and The Human Brain; to which is appended a brief bibliography and index.

The greatest interest naturally attaches to Professor Elliot Smith's standpoint on the controversial points concerning man's evolution and early man, and the following of his views may briefly be mentioned: The genus *Homo* developed from the stem of the Hominidae during the earlier part of the Pleistocene. The Pithecanthropus and the Eoanthropus were offshoots of the same stem, but not yet true men. The first branches of man are, as far as known, the *H. heidelbergensis*, *H. rhodesiensis*, and *H. neanderthalensis*, following which the *H. sapiens* comes into existence, giving off first the Australian race and a little later the negro; after which, following a reduction of the pigment in the skin, develop the Mongolian, Alpine, Mediterranean and Nordic races.

The stem of the human family rests in the Eocene, not however, on the Lemuroidea, which are a side development, but upon the Tarsoidea. The still very problematical "Hesperopithecus" is accepted as given by Osborn and Gregory, its sponsors.

As to the place of man's evolution, it was outside of Europe, and, so far as the author is aware "no one entertains the view that Man was evolved in Europe"—which is perhaps not quite correct; and he firmly believes in repeated immigrations into western Europe of more advanced types which displaced preceding populations, though he no more than other authors who advance similar views attempts to trace these "types" to their wholly nebulous abodes.

The whole book is written vigorously and the author is not afraid to express his opinions even though they may arouse controversy. The regret left after its perusal is due to the lack of attention to recent literature which bears on some of the important points under discussion.

O PŮVODU A VÝVOJI ČLOVĚKA, I BUDOUCNOSTI LIDSTVA (Origin, Evolution and the Future of Man. In Czech). By Hrdlička (Aleš)—12mo, 80 pp., Prague (B. Kočí), 1924.

Six lectures, delivered October 7–15, 1922, at the Anthropological Institute of the Czech University of Prague, on invitation by the University. The lectures, preliminaries to which were delivered at the American University, Washington, 1920–'22, deal with: I. The Origin of Man; II. The Place, Time and Causes of Man's Evolution; III. The Manner of Man's Evolution; IV. Man's Differentiation into Races and their Spread over the Earth; V. Man's Evolution in the Future; and VI. The Past and the Future of the Slav People.

The author shows that man's gradual evolution from a prehuman form (precursor) is already, notwithstanding the incompleteness of some of the evidence, one of the most thoroughly substantiated of major biological phenomena. He points out further that the process has not been and is not now everywhere equally active or effective, the result of which is human diversity; and that it is by no means completed or, as far as perceptible, approaching completion. Also, the process will probably not terminate in humankind as it has in so many lower forms, for man is progressing in knowledge and intelligence which will be applied to his self-preservation and facilitation of further advance.

The knowledge of man's evolution, the most wonderful of biological results, cannot possibly have any adverse effect on either faith or man's morality, any more than other formerly unknown truths have had or will have.

The exact causes, manner and locality of man's evolution are matters still largely problematical, nevertheless science is steadily approaching their solution.

Man's future evolution, as that in the past, is not without its serious dangers, and the role of natural selection with the survival of the fittest is not ended. The advance, according to all indications, will be primarily in the line of further refinement and increasing energy-capacity of the brain.

In the final chapter the author points out the fallacy of deriving the Slav peoples, whose cradle lies so plainly among the late paleolithic and neolithic populations of northern central Europe, from any hyopthetical "race" of either an unknown habitat or of Asia. As to their future, it lies essentially in the line of development of their, in certain respects decidedly, favorable intellectual endowments.

A SHORT COURSE ON PHYSICAL ANTHROPOLOGY. By M. R. Drennan, M.A., M.B., F.R.C.S. (Edin.), Professor of Anatomy, in the University of Capetown. (Demy 8vo., pp. 43; illus. 7.) Published by the author. Price 5s.

This little book has been compiled primarily for the use of students of anatomy in the University of Capetown. It contains a synopsis of the course of lectures on Physical Anthropology, which is given to medical students in that institution. Limited as it is in its scope, it nevertheless presents in a concise manner all the chief points which students can master in connection with this great subject.

The author commences with a brief introduction showing the position of man in the animal kingdom. He then proceeds to deal with the general principles underlying the study of physical anthropology, paying attention chiefly to the comparative features of the skeleton. All the most important characters, which can be determined by inspection are referred to, the method of taking the most generally accepted measurements is clearly indicated, and the significance of these and of the various indices, technical terms, etc., is explained.

The book closes with an all too brief account of some types of fossil and living races of man. In dealing with the living races the author confines himself almost entirely to a consideration of the fast disappearing "South African Bush Race," and he has gathered together an interesting assemblage of facts and measurements, many of them new, connected with this group of peoples.

Whilst adapted specially for South African conditions this little book gives a good general introduction to the subject of physical anthropology, and it cannot fail to be of value to all who are interested in this subject.

M. R. D.

PŮVOD A POČÁTKY LIDSTVA. (The Origin and Beginnings of Mankind. In Czech). By Matiegka (J.)—12mo, Prague ("Books for Everybody" Series, Státní Nakl.), 1924, 159 pp.

A very good semipopular outline of our knowledge concerning man's ascent, with due historical background. While covering much of the same ground as the preceding publication which appeared a little earlier, it by no means duplicates, but largely complements the same. It is a most fit little textbook for higher students, as well as a reliable and easily read book of information for thinking men and women outside of high schools and colleges. It comprises the following chapters: 1. History of Notions concerning Man's Evolution; 2. Review of the Evolutionary Theories; 3–5. Biological and other Evidence; 6. Embryological Data; Remnants of Organs, Anomalies; 7. The Evidence for Evolution of Physiology and Pathology; 8. Transitional Forms; 9. The When of Man's Appearance; 10. Paleoanthropology; 11. Objections; 12. The Age of Humankind; 13. The Early Home of Man; 14. The Causes of Human Evolution; and 15. The Manner of Human Evolution and Man's Genealogy.

A concise and wholly objective, high level work of this nature would be of much use in all languages.

THE MORPHOLOGY AND EVOLUTION OF THE APES AND MAN. By Sonntag (Charles F.)—8°, London, 1924, 364 pp., 59 illustrations. (John Bale, Sons & Danielsson, 12s/6d).

The book "is intended to serve as an introduction to Anthropology, for it deals with the first steps in that science, namely, the study of the relations of Man to the lower animals. It is based on observations made in the Anatomical Department and Ape House of the Zoological Society of London, and on the examination of specimens in the Museum of the Royal College of Surgeons of England, the Anatomical Museum of University College and the British Museum of Natural History." It includes an analysis of the large literature on the Apes. The contents are: Lemurs and Tarsius; New World Monkeys or Platyrrhini; Old World Monkeys or Cercopithecidae; External Characters, Habits and Classification; The Skeleton and Teeth; The Joints; The Muscular System; Organs of Digestion; Organs of Circulation, Blood and Ductless Glands; Organs of Respiration and Voice; The Urinogenital Organs; The Nervous System and Sense Organs; Evolution of the Primates; Bibliography and Index.

The book, though somewhat of the nature of a catalogue, is a mine of anatomical facts and will be indispensable to students of the subject; and it can attain even fuller value in future editions.

As to evolution of man, the subject is treated but briefly, and referentially rather than critically. The following paragraph summarizes the author's main view: "From a study of palaeontology we must confess that the actual common ancestor of Man and the large Apes is still as unknown as it was in Darwin's day; and it will be long before we can definitely point to it. We are unable to say with certainty that any of the Siwalik fossils is the common ancestor. But we know that none of the existing Apes is in the direct line of Man's descent."

WHAT IS MAN? By Thomson (J. Arthur)—Small 8°, N. Y. & London (G. P. Putnam's Sons), 1924, 331 pp., no illustr's.

The book contains ten lectures delivered in 1922 at the United Free Church College at Aberdeen. The object of these lectures was "to explain in a simple way how biologists regard man." The aim of the book "is to serve as an introductory to an all-round study of Man as Organism and Social Person;" and to give "an indication of the kind of knowledge that everyone should have of himself."

The sections are: Man's Pedigree; Primitive Man; Evolution of Man's Mind; Man as a Social Person; Behaviour and Conduct; Variability and Inertia; Sifting and Winnowing; Contact of Races; Disharmonies and Disease; What is Man not?. The subsection titles are even more attractive.

Professor Thomson is a well-known student of the questions he deals with. His book on "Darwinism and Human Life" has seen five editions. What he says on the subject of "What is Man?" is therefore well worth attention. And the book will not disappoint except perhaps the professional, and that in spots only. It is didactic. It is too brief in many parts, but that is consistent with its broadness. It contains many strong statements of thought as well as of fact. It well deserves to be read.

What may be criticized are some errors and some over- or hasty statements not thoroughly considered or whittled down. A few examples:

p. 20—under Neanderthal Man stands "500,000 years ago (?);" on p. 14 the Piltdown skull is referred to as possessing "a rather steep but apelike forehead;" of the Piltdown jaw, "the posterior part and the molar teeth are human." Since the discovery of the Neanderthal skeleton "many remains of the Neanderthal man have been found in France, *Spain*, Belgium, *Germany* and *Austria* (p. 15, italics by reviewer); the skull of the Rhodesian man (p. 17) is "laterally compressed;" the cradle of man is most probably central Asia (p. 22), because of "the antiquity of Asiatic civilizations; the Asiatic origin of most domestic animals; the Asiatic suggestion in some Cro-Magnon features; and the fact that the oldest humanoid remains (those of Pithecanthropus) are in Java"—reasons not one of which applies to man's fancied origin in central Asia; etc. etc. All this can however readily be corrected in a second edition.

The last chapter of the book and one in which its author is thoroughly at home, is on "What is Man Not?" It deals with the question of "What is Evolution; Trends of Evolution; Is Evolution going to stop; What is Progress; and How may Mankind make Progress." The answers are: "Organic evolution is a continuous natural process of racial change in a definite direction, whereby distinctively new individualities arise, take root and flourish along side of or in place of the originative stock. The concept includes man, though the factors in his case have changed greatly because of reason, society and purposeful control." The trends there are numerous, but "What is plain is that in spite of blind alleys, in spite of retrogressions, in spite of lost races, life has been on the whole creeping upward. As age has succeeded age, nobler and finer individualities have appeared, with more mastery, freedom and mind." Evolution is going on to-day and there are no indications that it will ever stop, though so far as physical man is concerned, anatomists on the whole do not look for startling changes in structure. Progress "means the fuller realization in an all-round balanced way of what the racial consciousness has most persistently held to be of the highest value;" and as to its continuation, "Evolution in the past has been, on the whole, towards integration, towards increasing fullness, freedom and fitness of life. There has been 'a constant if chequered advance'." The momentum of evolution is behind us still. Why should it and progress stop?

THE COMING OF MAN. By Tyler (John M.)—Boston, 1923, (Marshall Jones Co. $2.00).

This is the sixth volume in the series known as *The Amherst Books*, written by Amherst men. By the author of "The New Stone Age" and "Man in the Light of Evolution," this latest work embodies the mature conclusions of an emeritus biologist who has a gift for humanizing his science. "It is the story of the steps by which lower life grew into manhood."

The contents are: The Coming of Life; The Coming of a Backbone; The Rise of Land Life; The Coming of Savage Man; The Dawn of Civilization; The Rise of Personality; The Logic of Evolution; Nature and Man; Man and Environment; The Survival of the Fittest; and Perfect Health.

The book, particularly the biological part, is written well and with the vigor of a younger man. It makes good reading. It is also an exceptionally good example of book making and binding.

HUMAN ORIGINS: A MANUAL OF PREHISTORY. By MacCurdy (George Grant)—1924, New York & London. D. Appleton & Co., 2 vols., ($10).

In the words of the author: "In scope this work covers not only the origin and development of the genus *Homo*, but also the origin and development of human mentality reflected in man's discoveries, inventions and all the activities which enter into the warp and woof of human culture. Since it has to do with man's organic evolution as well as his cultural evolution, the name *Human Origins* has been chosen as the title best designed to describe the field to be covered. The theme of cultural evolution has received fuller treatment than that of organic, or physical evolution; hence the sub-title "A Mánual of Prehistory" . . . The studies that have culminated in these two volumes have covered a period of nearly thirty years and are based chiefly on the author's personal observations in the field supplemented by studies in the principal museums. The volumes therefore represent what the author has learned about human origins as revealed through researches in the European field."

The two books comprise the following sections: I—*The Old Stone Age and the Dawn of Man and his Arts:* The development of prehistoric chronology; the ice age and its bearing on man's antiquity; The Eolithic period; The Lower Paleolithic period; The Middle Paleolithic period; The Upper Paleolithic period; Paleolithic art; Fossil man; and Summary of the Old Stone Age. II—*The New Stone Age and the Ages of Bronze and Iron:* The transition from the Paleolithic to the Neolithic period; The Neolithic period; The Stone-Age culture complex; The Bronze age; The Iron age; and Physical characterisics of Post-Pleistocene man; with Appendices: Stratigraphic study of Paleolithic sites; Repertory of Paleolithic art; and On the preservation of prehistoric monuments.

The two volumes represent a highly creditable and laborious effort by one of our most conscientious students of man's antiquity. They are essentially informative, free from argument and individual theories, and contain a wealth of reliable information simply presented which will be of much utility to the American students of the great subject the author deals with. The many illustrations are well chosen and printed: a good proportion of them are original.

FOSSIL APES. EARLY MAN

Notes on the Type of *Hesperopithecus Haroldcookii* Osborn. By Gregory (William K.) & Milo Hellman—*Am. Mus. Novitates*, No. 53, Jan. 1923, 16 pp.

The authors' "results afford additional evidence in favor of Professor Osborn's conclusions that the type of *Hesperopithecus haroldcookii* represents an hitherto unknown form of the higher primates. It combines characters seen in the molars of the chimpanzee, of *Pithecanthropus* and of man, but in view of the extremely worn and eroded state of the crown it is hardly safe to affirm more than that *Hesperopithecus* was structurally related to all three.

"Whether *Hesperopithecus* itself is or is not ancestral to man can only be determined by subsequent discovery." Taking "the following definitely human specializations: (a) the reduction of the lingual root; (b) the lessening of the divergence of the lingual and buccal roots; (c) the widening of the antero-external root; (d) the antero-posterior shortening and transverse widening of the crown; (e) the tendency toward rectifying the asymmetry due to the narrowness of the posterior moiety of the crown, the *Hesperopithecus* molar shows the opposites of all these characters and such an assemblage of primitive features has not hitherto, so far as we are aware, been found in any single human molar.

"The anatomical, palaeontological, and other evidence already accumulated tends to show that man, *Pithecanthropus*, *Hesperopithecus* and the various anthropoids form a natural superfamily group, which may now be named the *Hominoidae*, in contrast with the *Cercopithecoidae*, or Old World Monkeys."

All of this, regrettably, is not wholly convincing, due on one hand to the badly worn and imperfect character of the type specimen, and on the other to its isolation. Further and more conclusive evidence on the subject is most desirable.

Further Notes on the Molars of Hesperopithecus and of Pithecanthropus. By Gregory (William K.) and Milo Hellman—*Bull. Am. Mus. Nat. Hist.*, XLVIII, Art. 13, 509–530, Dec. 1923. With an Appendix, "Notes on the Casts of the Pithecanthropus Molars" by Gerrit S. Miller, Jr.

The authors (Gregory and Hellman) have considered all the objections to and uncertainties connected with the identification of the fossil tooth in question as that of an anthropoid ape "and compared the type with the various specimens suggested, as well as with many others, but have returned with more confidence to the conclusions set forth above."

Miller addresses himself particularly to the teeth of the Pithecanthropus which have been drawn on for comparison by the other two authors, and his opinion based on the examination of many teeth of orangs as well as other anthropoid apes is as follows:

"Whatever the bones may prove to be, I think that the molars referred to Pithecanthropus are probably those of a now extinct Javan great ape representing the orangs of Sumatra and Borneo. Whether or not this ape was strictly congeneric with the orangs I am not prepared to say, because the teeth, like those of Hesperopithecus, are neither in sufficiently good condition nor in sufficiently great number to show what the animal's dental characters really were; but so far as they go, they come almost within the limits of individual variation of the living orangs, and in the slight peculiarities where they differ from orangs they do not approach men. Hence I think it is entirely misleading to speak of your fossil as showing resemblances "with Pithecanthropus and men rather than with apes."

UEBER DIE BREGMAGEGEND UND DIE LAGE DES BREGMA MIT BESONDERER BERÜCKSICHTIGUNG DES PITHECANTHROPUS. By Mair (R.)—*Z. Morphol. & Anthrop.*, 1922, XXII, 435–480.

Based upon the examination of the region of the bregma in fossil skulls and those of recent races, a series of interesting new conclusions are reached. In fossil skulls the area of the bregma is very frequently marked by a somewhat higher elevation than the surrounding parts. In modern primitive as well as higher races, an analogous elevation is not a rare finding. This eminentia bregmatica is frequently of a shape similar to the bregmatic fontanelle and is, in the author's opinion, caused by an increased pressure within the brain cavity which bulges out the great fontanelle during the entire time of its ossification. In an analogous manner the eminentia frontalis medialis (crista frontalis ext.) originates in consequence of a long vertical arm of the great fontanelle in connection with the intra-cranial pressure and is not due to the premature closure of the interfrontal suture, as commonly assumed. Metopism is often associated with this crista. In Pithecanthropus both the crista frontalis and the eminentia bregmatica are present and quite pronounced. Since the latter elevation corresponds to the great fontanelle, the bregma cannot be situated at its posterior end but, as could actually be shown in many skulls, lies always rather far forward on this eminentia. Schwalbe's determination of the bregma in the Java skull is therefore considered to lie too far back. The new position of the bregma would result in a number of craniometric changes, which in turn would give Pithecanthropus a somewhat different place in analytic comparisons with other crania. The supporting facts for these theories, which seem rather convincing, must be read in the detailed original.

A. H. SCHULTZ.

DIE MENSCHLICHEN SKELETRESTE AUS DEM KÄMPFE'SCHEN BRUCH IM TRAVERTIN VON EHRINGSDORF BEI WEIMAR. by Virchow (Hans)—4to, Jena, 1920, 141 pp., 8 tables, (Gustav Fischer).

On May 8, 1914, workmen blasting limestone at Ehringsdorf, near Weimar, brought to light fragments of a human lower jaw. After its repair in the local Museum, the specimen was sent to Gustav Schwalbe, who later in 1914 published on it two small reports. On November 2, 1916, in the same locality and again following a blast, there came to light portions of a child's skeleton, including its lower jaw. Both the previous and these latter remains lay in approximately the same stratum, about 70 feet from the surface of the ground and well over 60 feet below the surface of the limestone.

All the specimens were eventually turned over for description to Hans Virchow, and the present handsome volume is the result of his work.

The adult lower jaw was found 11.9 meters (39 feet) from the surface, in a pocket of unsolidified material, and from the vicinity of the bone were recovered remains of fossil elk, horse, ox, *Rhinoceros merckii*, and cave bear, also partly carbonised unidentifiable bones, charcoal and numerous stone objects and implements. The child's skeleton and also two small pieces of a skull, as well as some worked stones, were enclosed directly in the stone.

The physical characteristics of the jaws stamp them as belonging to the series of earlier Paleolithic remains. In the opinion of the author they are related to *Homo neanderthalensis*. The teeth are particularly interesting (see Vol. VII, No. 1 of this JOURNAL); they resemble especially some of those of Krapina and those of Le Moustier.

Ehringsdorf is less than three miles from Taubach, where Paleolithic human remains were found previously. It is undoubtedly one of the most important sites of early man so far discovered in southern Germany. The work in the quarry is proceeding under careful supervision, and in the latter part of 1922 resulted in the discovery of another human specimen, a femur, which is not yet described.

SUR LA DÉCOUVERTE D'HOMMES FOSSILES D'AGE AURIGNACIEN, A SOLUTRÉ (SAONE-ET-LOIRE). By Depéret (CH.), F. Arcelin and L. Mayet.—*C. R. Acad. Sci.*, Session of Oct. 8, 1923, CLXXVII, 618, 3 figs.; same published also in *La Nature*, Nov. 3, 1923, with additional illustr's.

The excavations conducted by the authors at Crot-du-Charnier (Solutré), not far from Lyon, during 1922–'23, resulted in a definite determination of the stratigraphy of this famous prehistoric site and in the discovery of several human skeletons of which two were of adult males. In the opinion of the authors these are of Aurignacian age and belong to the Cro-Magnon race, although the skulls are considerably shorter, the cephalic index reaching the uppermost limits of mesocephaly. Both the males were of adult stature (183 and 175 cm.).

According to later information the excavations have been continued during the summer of the current year (1924), and have resulted in the discovery of additional skeletal as well as archaeological material of value.

THE STONE EPOCH OF THE DUNES OF THE EASTERN PART OF THE MALOPOLSKA PLATEAU (In Polish, with Summary in German). By Kozlowski (Leon)—*Arch. Nauk Antrop.*, Warsaw, 1923, II, No. 3, small 4°, 27 pp., map and numerous illustr's.

A comprehensive archaeological work of much value for the study of prehistoric man in a large portion of Poland. Of interest to physical anthropology through chronological determinations. The remains of the many stations explored range in age from the upper Paleolithic to and through the Neolithic.

ANCIENT MAN IN BRITAIN. By Mackenzie (Donald A.)—8°, New York, 1923, XII+257 pp. (Frederick A. Stokes Co.)

"This volume deals with the history of man in Britain from the Ice Age till the Roman period. The evidence is gleaned from geology, archaeology, philology, ethnology, anthropology, etc., and the writer has set himself to tell the story of Ancient Man in a manner which will interest a wider circle of readers than is usually reached by purely technical books."

The seventeen sections of the book deal respectively with: Britons of the Stone Age; Earliest Traces of Modern Man; The Age of the "Red Man" of Wales; Shell Deities and Early Trade; New Races in Europe; The Faithful Dog; Ancient Mariners reach Britain; Neolithic Trade and Industries; Metal Workers and Megalithic Monuments; Celts and Iberians as Intruders and Traders; Races of Britain and Ireland; Druidism in Britain and Gaul; The Lore of Charms; The World of Our Ancestors; Why Trees and Wells were Worshipped; Ancient Pagan Deities; and Historical Summary.

The book is a careful, well-written, but cultural and historical rather than anthropological summary of facts; it is an able and broad-minded compilation rather than a report of scientific research. It disappoints somewhat the expectation raised by the title, but provides a very useful, high-class text-book on later man of the British Isles.

DIE MENSCHENKNOCHEN DER MEGALITHISCHEN GRABKAMMER BEI SVELVIK IN NORWEGEN. By Schreiner (K. E.)—Christiania, 1923, royal 8°, 75 pp., 9 pl., 52 text fig's. (Steenske Forlag.)

A handsome, beautifully illustrated report, dealing with the most important so far discovered neolithic skeletal remains in Norway. The Svelvik skeletons, three in number, proceed from a megalithic burial.

The main value of the report lies in the detailed critical treatment of the bones of the skeleton, particularly the long bones.

The study is to be followed by one on the skeletal remains of Norway from the bronze and iron periods, a most useful undertaking.

EINIGE BEMERKUNGEN ZUR FRAGE DER STEATOPYGIE DES PALÄOLITHISCHEN MENSCHEN. By Želízko (J. V.)—*Sitzb. Anthrop. Ges.*, Wien, 1921–2, 22–25.

Basing himself on a good review of the known representations of the female human figure (which are much more common than those of the male figure) from the later paleolithic times, the author comes to the conclusion that during the Aurignacian period there has probably existed somewhere in western Europe a race of people whose women were characterized by more than the modern average of prominence of the gluteal region.

HEREDITY—EUGENICS

RESEARCHES INTO ANTHROPOLOGICAL HEREDITY: I. Inheritance of Eye Color in Man; and II. The Genetic Relation of Index cephalicus. By Byrn (Halfdane)—*Hereditas*, 1920, I, 186–212.

Careful studies based on the examination of 834 individuals of all ages, from small children to grown-ups, in two much isolated mountain districts of Norway, namely Selbu and Tydalen. The conclusions are both interesting and valuable. The author points out the difficulties encountered through the changes with age in pigmentation. "The great difficulty met with in this kind of investigations is the constant development of many of these features throughout life. Many born with blue eyes have 'mixed' eyes when one year old, brown eyes when 4 years old. A fair-haired two-years old child becomes light brown haired at the age of 12 and dark brown haired at the age of 30.

The results of the work are summed up as follows:

Pigmentation of Eyes: If both parents and all the grandparents have blue eyes (without brownish pigment) all the children will have blue eyes.

If both parents have blue eyes while some of the grandparents have eyes with brownish pigment some of the children (ca 10%) will also have eyes with brownish pigment, while the rest will have blue ones.

If both parents have eyes with brownish pigment an average of one-fourth of the children will have blue eyes and three-fourths will have eyes with brownish pigment.

If one of the parents has brownish-colored eyes, the other having blue ones, there will be an average of one-half of the children with blue eyes and one-half with brown eyes.

If both parents have 'mixed' eyes, an average of one-fourth of the children will have blue eyes, one-fourth plain brown eyes and two-fourths 'mixed' eyes. This rule is perhaps not applicable to all types of 'mixed' eyes. So it does not seem to apply to blue eyes with a well defined brown ring around the pupil. If both parents have this special type of 'mixed' eyes, all the children get the same type of 'mixed' eyes.

In our population there are probably three biological types with regard to eye color: (a) The plain blue type; (b) The plain brown type; (c) The light 'mixed' type where there is a narrow but well defined brown ring around the pupil, while the rest of the iris is blue.

These different eye types interbreed in accord with the Mendelian laws of heredity, viz. blue eyes are recessive to all types of eyes with brownish pigment.

Cephalic Index: Three biotypes are found in Selbu and Tydalen with regard to index cephalicus, whose indices are about 73, 77 and 83 respectively.

These types segregate when interbred in accord with the Mendelian laws in everything essential.

The brachycephalic type is dominant to both the others.

The dolichocephalic type is too rare to allow any positive conclusions; it seems however to be dominant to the mesocephalic type and recessive to the brachycephalic type."

IS THE CHINESE HEREDITY INFERIOR? By Wang (Cho)—*J. of Hered.*, 1922, XIII, No. 3, 99–102.

The author's answers to the above question are: "The modern Chinese are derived from the mixing of many highly endowed tribes. In an over-populated country like China natural selection in the form of diseases and famines has been very severe. There are many Chinese religions or customs which are eugenic, such as ancestor worship, large family system, early marriage, etc. There is a predominant rural population—85 per cent according to the best available statistics—and the farm is the best habitat for human beings."

HEREDITY AND EUGENICS. By Gates (R. R.)—8°, 1923, xiii+288 pp., New York (Macmillan Co.).

This is a text book of eugenics which lays especial stress on human heredity. In a final chapter some social aspects of eugenics are considered. The author's first chapter is a discussion (somewhat inadequate since so brief) of the general aspects of heredity, a subject to which the author has contributed much by his own researches. Then follow about 118 pages on inheritance of physical characters in man, containing many pedigree charts. Mental characters are discussed in some 30 pages and "the limits of heredity" in 29 more—dealing with such phenomena as twins, finger prints and lethal factors. There is a bibliography of 19 pages. The whole forms a useful compendium. If one is to criticise one may say that the material of the book seems not always completely digested. One paper after another is taken up in order and abstracted, though not always critically. But is it, perhaps, too early for a critical work on human heredity.

C. B. DAVENPORT

THE HIGHER EDUCATION OF WOMEN AND RACE BETTERMENT. By Dublin (Louis I.)—*Eugenics in Race & State*, 1923, II, 377–385.

"The education of women to-day is a disgenic influence. It is leading women away from matrimony and child bearing. As education is here to stay, it must be modified in form and content to serve community welfare rather than to hamper it . . . Curricula must be shaped to result in the development among the students of interest in the activities of home life as a personal ideal . . . Graduates of women's colleges should set the fashion for good sized families and should combat the fallacy that marrige means sacrifice of power or sinking into mediocrity . . . most important, there must be a change in fashion which will make it unapproved for healthy and self-sustaining men or women to remain unmarried."

MIND AND HEREDITY. By Kellogg (Vernon L.)—8°, Princeton University Press, 1924, 108 pp. ($1.50.)

A delightfully written, high class primer on Mind and the inheritance of its qualities; the only regret being that the author had to draw, for parts of his conclusions, upon the necessarily imperfect results of mental tests made during the world war on the drafted men of the American army. The contents are: Introduction; The Instinct Mind of Ammophila; Reflexes of Honey-Bees and Silkworm Moths; Other Reflexes and Tropisms; Intelligence and Reason; The Inheritance of Mind; Intelligence Tests; Education and the Mind; Societal Organization and Mental Capacity; Racial Traits and Immigration; and Heredity and Environment in Mind Determination. All these matters are dealt with in a thoroughly enjoyable and understandable manner. The author naturally stresses the importance of heredity in the determination of mind and character; but he also points out the importance on these of modifying, particularly environmental factors, including education.

A BIBLIOGRAPHY OF EUGENICS. By Holmes (Samuel J.)—*Univ. Calif. Publ. in Zool.*, XXV, 1924, 1–514.

This volume represents a vast amount of unselfish work, for which students in eugenics as well as anthropology will be very thankful. It grew out of a list of references collected by the author during the preparation of his book "The Trend of the Race" (ref. this JOURNAL V, 1922, No. 1, 71). The richness and importance of it to anthropology will best be seen from an enumeration of its sub-divisions, which are: Heredity and Evolution; Eugenics and Works of a General Character; Genealogy; The Problem of Degeneracy; Alleged Increase of Insanity; Heredity of Human Traits; Heredity of Human Defect; Inheritance of Feeble-Mindedness; Inheritance of Epilepsy; Inheritance of Insanity; Inheritance of Deafness; The Hereditary Factor in Tuberculosis; Alcohol and Heredity; Racial Influence of Venereal Disease; The Hereditary Factor in Crime; in Delinquency; in Prostitution; Pauperism and Vagrancy; Inheritance of Mental Ability; Genius and Insanity; Race; The Birth Rate; Neo-Malthusianism—Birth Control; Natural Selection in Man; Selective Effect of Infant Mortality; Selective Influence of War; Sexual Selection in Man; Urban Selection and the Influence of Industrial Development on Racial Heredity; Racial Influence of Religion; Immigration and Emigration; Consanguinity; Race Mixture and the Intermarriage of different stocks; Determination of Sex; Sex Ratio; Age of Parents and Offspring; Order of Birth and Offspring; and Negative Eugenics.

The one desideratum in connection with this very deserving work is that it may be supplemented by an Index of Authors. A much greater wish is that something similar may one day be produced for Physical Anthropology. It would be of the utmost utility.

RACES — PEOPLES

LES RACES ET L'HISTOIRE: INTRODUCTION ETHNOLOGIQUE À L'HISTOIRE. By Pittard (Eugène), L'Évolution de l'Humanité, ed. Henri Berr, No. 5—Paris, La Renaissance du Livre, 1924, Pp. xx, 621. (20 fr.)

A book on "The Races and History" by Professor Pittard, the well known Swiss anthropologist, deserves serious attention. At the same time, however, his name in a case such as this becomes a disadvantage to the author by arousing in his reader high expectations that can not perhaps always be met, and if they are not met, subjecting him to a more severe criticism than would be addressed to a man of lower position.

The volume, a small octavo of 620 pp. (with a number of text figures), is the fifth of a series on "Evolution of Humanity" being issued by the above Paris publishers; but is actually the eleventh volume completed of the 26 which are to compose the whole series—a characteristic French production. The previously issued monographs are: La Terre avant l'histoire; L'Humanité préhistorique; Le Langage; La Terre et l'évolution humaine; Des Clans aux Empires; La Mésopotamie et les civilizations babylonienne et assyrienne; La Civilization égéene; La Formation du peuple grec; L'Art en Grèce; and La Pensée grecque et les origines de l'esprit scientifique.

The book contains the following chapters: Race and History (p. 5); Classification of Human Races (33); Races and Languages (55); Primitive Human Races (64); Races of Europe (95); The Iberian Peninsula (114); France (141) and the other European nations; the Races of Asia (377), of Africa (505), of America (533), and of Oceania (559); with Conclusions (577–591), Bibliography (593–607) and Index (609–616).

In looking over the text it is found that the various subdivisions are not of equal value, which is perhaps natural. Those on peoples with whom the author is more directly acquainted through his own affiliation or work are superior to others. On the whole, however, there is included in the work much anthropological information. The book differs in fact from all previous ones of related nature in dealing with the subject of European peoples from the anthropological and not the historical point of view, due to which fact it cannot but prove generally useful and interesting.

To the professional anthropologist, however, it is not all that could be desired. The writer employs extensively the form of questions where one could wish for information or opinion; there is not enough of detail; and there is too much reliance on the racial significance of the various anthropometric characters and especially indices, which is not in harmony with the most modern views and experiences. But the book was not written for professionals.

To those interested in American anthropology the section of greatest interest will naturally be that dealing with the indigenous people of the new continent and here unfortunately the author, in common with so many European anthropologists, is at a considerable disadvantage. He is not himself a direct student of the American aborigines, and evidently he is not sufficiently acquainted with the American literature dealing with the Indian, for in his entire bibliography he mentions not one single contribution of an American author to the physical anthropology of the Indians, even though a thorough summary of this has now been available for a number of years (A. Hrdlička—Physical Anthropology: Its Scope and Aims: Its History and Present Status in the United States. 8°, Wistar Inst., Phila., 1919). The results are correspondingly imperfect. Professor Pittard still holds to the belief of the presence in America of geologically ancient man. He still holds to the Lagoa Santa "ancient race." For him the problems of the origin and unity of the Indians are still unsolved. He sees in America more than one people, about whose affiliations, derivation, mode and time of coming, etc., he is very uncertain. His information about the distribution of physical types among the Indians is of older date and as such is inadequate. Under these conditions and with his caution he could scarcely have arrived at a different view than that the origin and racial composition of the American Indian are matters still problematical, that those who hold more definite opinions are biased, and that we must await the discovery of their fossil ancestors to obtain true light on the Indians. All of which could have been written with justification a few decades ago, but is not in keeping with recent substantial developments of American anthropology.

In Professor Pittard's "Conclusions" there are too many questions. In the first section (pp. 577–579) there are eighteen sentences ending in a question mark, to nine and those mostly subsidiary ones, ending in a period. Thus the part brings to the reader rather a mass of problems and uncertainties than definite information or judgment. The author himself recognizes this defect; he cautions the reader not to become prejudiced on this account against "Ethnology." In many points the science cannot as yet give definite answers to important and complicated questions. "But how much more knowledge we possess to-day on such problems than we did 50 years ago!"

The author's main desire is that the present volume should arouse further interest in anthropological facts and researches, particularly in the wider circles which will be reached by the publication. He finishes by strongly calling attention to the practical services which anthropology has already rendered and will yet give to humanity.

Race Prejudice. By Finot (Jean), Translated from the French by Florence Wade-Evans. 8°, New York (E. P. Dutton & Co.), 320 pp.

This would be a well justified treatise, directed against the egotistic, political, demagogic or emotional exaltation of ones own and debasement of other races, which in many parts of the world has undergone such a resurgence since the beginning of the World War, were it not irremediably biased in the opposite direction.

As it is, the author shuffles with and openly abuses anthropology, without knowing or understanding it. Moreover he lives essentially in the past, somewhere about the middle of the second half of the nineteenth rather than in the twentieth century, barely touching the latter here and there. He is not even aware of the great new drive of and for the "Nordics," still calling them by their now almost forgotten earlier epithets of "Aryans" or "Europeans;" and while thoroughly well meaning he hurts rather than benefits the negro by trying to raise the race, belated through climate and disease, to equality with the ever onward forced and forging white man.

The best parts of the book are those in which the author shows by profuse historical evidence the thoroughly mixed origins of the main European nations; fortunately these chapters constitute the bulk of the text.

A high-class popular work combatting unjustified assumptions of racial differences, racial bias and jingoism is indeed a great need to-day, particularly perhaps in America; but to be effective it must be written by one with the highest modern attainments and deep, direct, scientific knowledge of peoples. Sympathies alone are not sufficient.

THE RACES OF ENGLAND AND WALES. By Fleure (H. J.)—12mo., London, 1923 (Benn Bros., 5/s), 118 pp., 11 plates.

A very useful little book which, it is hoped, may before long see a revised and enlarged edition.

The author gives a summary of the main conclusions of recent research and proceeds with discussion, with the avowed purpose however that one of the chief aims of the monograph is to promote further intensive research on the subject it deals with.

That such research is much needed must be only too evident to any student of the racial history and anthropological characteristics of the people of Great Britain. As to anthropological data it is no exaggeration to say that many tribes of savages within the British dominions have been more thoroughly studied, for outside of records on stature, weight, pigmentation and the cephalic index, there is but little information on the living Englishman, Scotchman and other contingents of the British people.

There are some misprints in the book (*e. g.* upper three lines of second paragraph, p. 15; line 15, p. 35, etc.), most of the illustrations are too small and the bibliography needs additions, but that does not detract from the distinctive value of the book for those who wish to learn what anthropologically is known about the "races" of Wales and England.

THE HOME OF THE INDO-EUROPEANS. By Bender (Harold H.)—12mo, 1923, 59 pp., 2 maps (Princeton Univ. Press, $1.00).

The author, Professor of Indo-Germanic philology at Princeton University has given herewith a good little book, which deserves not merely to be widely read but also used.

Pointing out the difficulties that to this day surround the question of the identity of the Aryan people, he says (p. 6) "And to make confusion worse confounded an unfortunate element has been introduced into the discussion, particularly within the past decade, when national glorification of self and calumniation of foe induced even scholars of repute to trace the ancestry of their enemies to Belial and that of their friends to the Indo-European prototypes of the Patroons, Pilgrims and Puritans. Germans insist that they belong to the Nordic race and that the Nordic race is the pure Indo-European stock. French, English and American writers claim that the Germans are not Nordics, or, if they are, then not the Nordics but the Alpines are the true Indo-Europeans.

"No definite answer to this great question is as yet scientifically justified. But a probable, tentative, general solution is slowly crystallizing in the minds of many philologists—and the problem is primarily a linguistic one."

His conclusions are that the Indo-Europeans developed originally in Eastern Europe: "No other part of Europe or Asia agrees so well with the historical distribution of the Indo-Europeans, with the relations of the various languages to one another (for example, Indo-Iranian and Balto-Slavic, Slavic and Germanic, Lithuanian and Slavic, Italic and Celtic), and with all that is known or surmised of the primitive Indo-Europeans.

"This region lies at the center of Indo-European territory; it is situated between the *centum* and *satem* groups of languages; it is adjacent to the Finno-Ugrian with which Indo-European must very early have come in contact, as is shown by prehistoric borrowings on the part of the former; it includes the most conservative of Indo-European peoples and the most archaic of their languages; it offers abundant remains to prove that it was a centre of Neolithic civilization, although the study of Russian and Polish and Lithuanian prehistory is still in its infancy; it nourishes every plant and animal that we have the slightest reason to consider Indo-European; it contains great plains such as the Indo-Europeans required for the grazing of their numerous cattle, and fertile valleys for the pursuit of their agriculture; it embraces the forests that are indicated by the names of certain Indo-European trees and animals; it is bisected by the beech line; it is the home of the birch; and it is the home of the honey-bee. No other region dovetails so well with what is known of Indo-European pre-history."

IRANIANS AND GREEKS IN SOUTH RUSSIA. By Rostovceff (M.)—Oxford Univ. Press, American Branch. Pp. XVI+260, 32 pl., 23 fig. in the text and a sketch map of South Russia. ($23.35).

A learned and important monograph on the history of South Russia and the development of its civilization, of indirect but real interest to physical anthropology. On the basis of a detailed and minute analysis and comparison of the enormous archaeological and art material which the graves of that region have yielded, the author undertakes to construct a synthetic history of South Russia from prehistoric times (the neolithic and chalcolithic age) down to the period of the migrations in the fifth and sixth centuries A. D., so as to establish the part played by South Russia in the history of the world in general, and to point out its contribution to the civilization of mankind.

Already the men of the neolithic and chalcolithic age were not wholly primitive as witnessed by the remains of their painted pottery which are dated in the third millenium B. C., and have their parallels in Mesopotamia, Egypt and Turkestan. The invaders who followed in were not mere transitory passengers but sojourners in settled states and kingdoms, which resulted in the formation of material cultures combining various elements. The producers of the copper culture on the Kuban were the Maeotians (derived from Maeotis, the ancient name of the Sea of Azov), the Sauromatians (not to be confounded with the Sarmatians) and the Gindians. At an unknown date the Cimmerians, Indo-Europeans of probably Thracian origin, appeared in South Russia. The Cimmerians in turn were conquered in the seventh century by the Scythians, an Iranian tribe with an infusion of Mongolian and Turanian blood, who founded a kingdom which was almost completely Iranian, a sort of a northern counterpart of the kingdom of Darius and Xerxes. The Sarmatians who conquered the Scythians in the third century B. C., were likewise Iranians. These successive invaders formed but a minority of the population in the territories which they occupied, but they constituted the ruling class, and the civilization which they developed was an aristocratic-nomadic one. It was mixed and a composite civilization: 1. the native element; 2. an Oriental stream from Mesopotamia by way of the Caucasus and from Asia Minor, and 3. a Greek stream. "The Scythian art at the outset was a branch of that mixed Iranian art of which hitherto we knew only the Persian branch." The Sarmatians, who pushed the Scythians to the Crimea and the Dobrudzha, brought, like the Scythians, a high culture with them and adopted elements from Greek and Greco-Scythian civilization. They, in combination with the Alans, also Iranians, became a peril to the Roman Empire. From the second century B. C. to the third century A. D. the Sarmatians, and especially the Alans, were the predominant force throughout South Russia and Western Asia.

In summing up Professor Rostovceff traces three main currents in South Russian civilization: an eastern current, proceeding from Iranian and Mesopotamian Asia; a southern current from Asia Minor and Greece which brought with it the splendid civilization of Greece, and a western and northern current by means of which Russia partook in the civilization of central and northern Europe. With the defeat of the Huns the Slavic Russians became the heritors of all the predecessors in the fifth and sixth centuries A. D. and founded the Russian state with Kiev as its centre, which subsequently became the mother of other states east and west, and even of Russia of the present day.

The book is provided with a copious bibliography and a full index. The typographical features of the book, both as regards the letter press and the illustrations, is above praise. But this does not seem to justify the exceedingly high price which will render this valuable work inaccessible to most of those for whom it is supposed to be intended.

I. M. CASANOWICZ.

LA MÉSOPOTAMIE. LES CIVILIZATIONS BABYLONIENNE ET ASSRYRIENNE. By Delaporte (L.)—8°, XIV+420, map, 60 text figs.

LA CIVILIZATION EGÉENE. By Glotz (G.)—8°, VIII+471. 87 figs., 3 maps.

LA FORMATION DU PEUPLE GREC. By Jardé (A.—8°, XII+425, 7 maps.

The three volumes are parts 8, 9 and 10 of the series "L'Evolution de l'humanité," edited by Henri Berr and published by La Renaissance du Livre, 78 Boul. Saint-Michel, Paris, at 15 fr. each.

Each of these books gives a detailed account of the history, institutions, religion, art, etc., of the people it deals with. The present review, however, will confine itself to matters of anthropological interest.

When man settled in the Valley of Mesopotamia he already possessed a relatively high culture. The deepest strata, however, show traces of neolithic industry. The valley was inhabited by two distinct races; in the south non-Semites, called Sumerians, of a stocky, underset, brachycephalic type; in the north Semites, called Akkadians. It is uncertain which was the first comer. To the mingling of these two elements, the Sumerian and Semitic, Babylonia owes an original civilization which by the side of the Egyptian is the oldest and most remarkable.

In the history of Mesopotamia, the year 2225 B. C. is an important date, for in that year the first Amorite dynasty was established. For the period preceding no reliable chronology exists. Sumu-Abu, the first king of this dynasty, extended his rule over Sumer and Akkad and realised definitely the union of both countries under the same sceptre. The Sumerian race was partly annihilated, partly assimilated.

The Assyrians formed already in the 25th century B. C. a distinct people. Their origin is equally unknown. They seem to have been, in the third millenium, spread over a great territory from which they were driven to Assyria proper by Aryan peoples. Professor Delaporte seems to ignore the view of some Assyriologists that the Assyrians were "Babylonianized" Hittites as the Babylonians were "Sumerianized" Semites.

The Aegean peoples are dealt with by Professor Glotz and his statements are based especially on the discoveries in Crete.

Crete's first known population is that of 6000(?)–3000 B. C. Between the stone age and bronze age the author sets a chalkolithic period, 3000–2400. Then follows the first bronze age, 2400–2000, the first flowering up of Crete's power and hegemony 2000–1750, and the second hegemony 1700–1400, paralleled by the early Mycenaean period 1600–1400. At the end of this period is perhaps to be assumed the temporary setback of Cretan civilization following upon the influx of the Achaeans from the continent, so that from 1400–1200 Mycenaea assumed the lead. Finally in 1200, the Dorian invasion overthrew the Cretan power. While "the submission of Crete to the Achaeans (was like) the conquest of Greece by Rome *capta ferum victorem cepit*, the arrival of the Dorians was the invasion of barbarians."

In the chalkolithic period the autocthonous people were oblong-headed, but mingled with certain elements of round-heads. The predominant type was now Mediterranean, now Asiatic. The brachycephals represented either the surviving remnant of the aborigines or an immigrant element. From the mingling of the two types issued a considerable number of mesocephalic half-breeds. With the invasion of the Hellenes (Achaeans and Dorians) the proportion of dolichocephals changed from two-thirds to one-eighth with a corresponding increase of the brachycephals and mesocephals resulting from the extermination or flight of the greater part of the old inhabitants. This is confirmed by observation of the present day Cretans. The stock of the race remained what it had been made through the Achaean and Dorian invasions. The mesocephals form the majority, the dolichocephals of the Minoan times have perpetuated themselves in the extreme west of the island and on the isolated heights, while the impenetrable lair of the Sphakioks includes most of the brachycephals and they also best maintain the speech and the warlike spirit of the Dorians. The old Cretans were, as attested not only by the measurements of the few skeletons found but also by paintings, reliefs and engraved gems, of small stature. This was compensated by a certain nervous suppleness. Men are represented on paintings browned, women with white skin, due to the different mode of life.

Regarding the Greeks, Professor Jardé says in the Introduction: "It is impossible to separate the Greeks from the land in which they lived; if the *milieu* did not create the qualities of the Hellenes, it favored their development. On the other hand the idea of race is too obscure to afford clear explanations. From the most remote antiquity there is no physiologically pure race, but mixtures of races and peoples . . . influences of *milieu* and innate qualities are not negligible, but they combine differently according to the evolution of each group."

As in the general area of the Aegean, so also in Greece, the earliest so far known traces of man belong to neolithic, or rather eneolithic times, characterized by the first copper utensils. The first population was that of primitive barbarism. These peoples who spoke non-Indo-European languages are known as Pelasgians—a name adopted for mere convenience for it is not known who the Pelasgians really were. From Egyptian documents we learn that towards the end of the 15th century another people appeared "the people of the sea" who threatened Egypt; and these became the ancestors of the classic peoples of Greece and Asia Minor. They may be called Achaeans, a name of similar conventional meaning of Pelasgians. By possession of bronze arms they brought about the fall of the Cretan civilization, and from the combination of the Aegean-Cretan and Achaean elements was formed the Mycenaean civilization. The Achaeans in turn yielded to the Dorians who were in possession of iron weapons. While the Achaeans and Aegeo-Cretans are believed to have had nothing in common, the Dorians and Achaeans were apparently but tribes of the same people.

As regards the physical type of the Greeks, at present of the three races into which the Europeans are divided, two predominate in the Balkans; on the coasts the *Homo mediterraneus*, in the interior the *H. alpinus*. But this is no certain index of conditions in the past. Paintings and sculpture afford no assistance. The measurements of the few skeletons and skulls extant are, on account of their variety, difficult of scientific interpretation. The anthropological data are so varied as to suggest much mixture in the classic Greek people. On the whole it may be said the Greek was mainly Mediterranean, but with considerable admixture. The straight narrow nose may be the inheritance from a northern strain. The author refrains from introducing into Greek history the factor of race.

Of all the three volumes under discussion it may be asserted that they exhibit a comprehensive and solid resumé of present day knowledge of the people of which they treat. A select bibliography, tables of contents and good indexes accompany each volume.

I. M. Casanowicz.

A History of the Arabs in the Sudan and some Account of the People Who Preceded Them and of the Tribes Inhabiting Darfur. By Macmichael (H. A.)—8°, (Cambridge University Press), 2 vols., 347 & 488 pp., 1 map.

A scholarly, elaborate work, dealing with: the Inhabitants of the Northern Sudan before the Time of the Islamic Invasions; the Progress of the Arab Tribes through Egypt; the Arab Tribes of the Sudan at the Present Day; and the Native Manuscripts of the Sudan; to which is added a very good bibliography.

The work will be a well of information for all students of the complex questions of the Arabs and also other peoples in Egypt, Nubia and other parts of North Africa. It is of course a work to be consulted rather than read. One can hardly abstain from the wish that besides this exhaustive treatise the author had given us also a good synopsis embodying the main results of this great research.

The two volumes are printed in excellent form and on a high class paper.

The Anthropology of the Chiltern Hills [England]. By Bradbrooke (W.) and F. G. Parsons—*J. R. Anthrop. Inst. Gt. B. & Ire.*, 1922 LII, 113–126.

"The present-day inhabitants of the North Chiltern area, who are not recent immigrants, are distinctly darker haired than those surrounding them; and the facts at our disposal make us think that this darkness is due to the survival of a greater proportion of Neolithic or Mediterranean blood in the district."

TROMS FYLKES ANTROPOLOGI. By Bryn (Halfdan)—(*Videnskapsselskapets Skrifter* I, Math.-Naturv. Klasse, 1921, No. 20). Repr., 8°, Christiania, 1922, 176 pp.

A detailed, painstaking anthropometric study on 662 military men of 20–21 years of age from the district of Troms in the northwestern most portion of Norway, settled by the present population since about 1,000 B. C. Of this population 90 per cent regard themselves to be Norwegians, 8 per cent as Lapps (mostly mixed) and 2 per cent as Finns. The study shows the people to be in the mean well above the European medium in stature (169.3 cm.), subbrachycephalic (C. I. 80.7), mesoprosopic (F. I. 85.1), leptorrhinic (N. I. 68.5) and generally light eyed as well as light haired. The admixture of Lapps and Finns has had no appreciable effect.

DIE ANTHROPOLOGISCHE ERFORSCHUNG FINNLANDS. By Hildén (K.) —*Arch. f. Anthrop.*, 1922, N. F. XIX, 36–40.

In this review of the various physical anthropological investigations on Finns it is shown that the average stature of the different groups of true Finns (not including the 11.3% of Swedish population and the few Lapps) vary between 164.4 and 168.6 cm., the cephalic index between *79.4* and *82.6*. Eyes of light color occur in 78 per cent and blond hair in 57 per cent of the Finns. The exact systematic position of the Finns cannot as yet be determined, but the author emphasizes that they have nothing in common with the Mongolian race, as was frequently assumed.

A. H. SCHULTZ.

SERBOWIE (THE SERBS). By Wrzosek (Adam)—*Wiadomosci antropologiczny* (Poznań), 1922, I, 29 pp.

Measurements of 124 men, war-captives, 24–50 years of age. Mean stature, 168.5 cm.; length of head, 18.2; breadth of head, 15.5; cephalic index, *85.5;* breadth of face 14.2; length of nose, 5.01, breadth, 3.38, index, *67.6*.

Report also gives result of numerous visual observations. It is provided with an abstract in French.

ANTHROPOLOGISCHE UNTERSUCHUNGEN AN SERBISCHEN ZIGEUNERN. By Lebzelter (Viktor)—*Mitt. Anthrop. Gesell.*, Wien LII, 23–42.

The author records here the results of his measurements and observations on 41 male Serbian Gypsies taken as captives or interned in Austria during the world war. He assumes definitely that the original home of the gypsies was north-western India. He gives a brief account of literature relating to their identification with a short chronological history, bibliography and portraits of four of the subjects examined. For the anthropometric details the reader should consult the original.

BEITRÄGE ZUR PHYSISCHEN ANTHROPOLOGIE DER SPANIOLISCHEN JUDEN UND ZUR JÜDISCHEN RASSENFRAGE. By Wagenseil (F.)—*Z. Morph. & Anthrop.*, XXIII, No. 1, 33–150.

This interesting and detailed work, which regrettably lacks a good résumé, is based on the measurements and observations of 142 male and 62 female Spanish Jews of Constantinople (and other localities). The report includes comparisons with other Jews and also Armenians; and added to it are tables of detailed measurements as well as numerous portraits of the subjects examined.

BURIALS OF THE FIRST DYNASTY. By Flinders Petrie (W. M.)—*Man*' Sept. 1922, XXII, No. 9, 129–130.

Report on the discovery of approximately 500 graves of courtiers from the first Dynasty, near Abydos. About 80 skulls were obtained and brought to London. A few complete skeletons were also secured and all the long bones and skulls measured; but none of the data on these skeletal remains are given in the preliminary report.

THE LHOTA NAGAS. By Mills (J. P.), with Introduction and Supplement by J. H. Hutton—8°, London (Macmillan & Co.), 1922, 255 pp., 3 maps, 26 illustr's.

A valuable contribution to the ethnology (customs, religion, folk-lore, language) of the Naga tribes of Assam. The parts of interest to physical Anthropology are those dealing with the origin, mixture, migrations, and the appearance of the people. We learn that "the Lhota Nagas are a tribe numbering some twenty thousand souls, occupying a piece of territory that may be roughly described as the drainage area of the Middle and Lower Doyang and its tributaries down to the point where it emerges into the plains." The problems of their origin and composition are still awaiting solution. That they are a mixed people containing elements of both white (originally) and the yellow-brown race is certain. They vary in color from light to medium brown, "the inhabitants of the low ranges tending to be darker than those of the high villages." The complexion is sallow, the hair "as a rule straight, though wavy and curly hair is often seen in the villages near the Ao border," where there is evidently an admixture of Ao blood. "The hair of a Lhota child is brown with a distinct rusty tinge, becoming black in the adult . . . Middle-aged and elderly men sometimes have considerable beards . . . The eyes are brown and slightly oblique in many individuals, the scantiness of the outer half of the eyebrows accentuating the Mongolian appearance of the face. Men average about five feet eight in height and women some three inches less. In build the Lhota is slight, but strong and wiry, though he has not the enormous calf development of the Angami. The hands and feet are small and well formed. The big toe is set rather far apart from the others, and a Lhota talking will often pick up a stone in his toes and tap the ground with it, just as a European might pick up a pencil in his fingers and fidget with it."

PHYSICAL ANTHROPOLOGY IN THE INDIAN ARCHIPELAGO AND ADJACENT REGIONS. By de Zwaan (J. P. Kleiweg)—8°, 1923, Amsterdam (in connection with the *K. Akad. v. Wetensch.*), 30 pp.

A valuable publication, in English, giving in brief a survey of anthropological work in the far eastern Dutch dominions and some neighboring territories, for which all students in these lines will be grateful. Much more has been done in these regions than is generally appreciated; nevertheless "much information is still required, much remains to be done, for hitherto the observations and measurements have generally referred only to small numbers of individuals and are, therefore, sometimes of comparatively little significance, rather fragmentary. Moreover, the material for investigation has not always been collected with proper judgment by trained men. In vast tracts of the Dutch East-Indies no anthropological investigations have been made whatsoever; these large fields are lying fallow.

"In future similar systematic investigations would need to be extended to a larger scale, by skilled investigators trained for the purpose and conducted according to a fixed method of investigation. Above all more attention should be given in Asia and Oceania than has hitherto been the case, to the investigation and study of prehistoric anthropological material."

A unique nice feature of the report are the portraits of the principal contributors to the anthropology of the regions in question.

THE KHASI AND THE RACIAL HISTORY OF ASSAM. By Dixon (R. B.)—*Man in India*, 1922, II, Nos. 1 & 2, 1–13.

The author has measured 25 male Khasis. The cephalic and nasal indices obtained signify to him that the Khasi "in spite of their linguistic isolation among the peoples of Assam, are racially closely related to the majority of the Tibeto-Burman tribes. With them they represent a very old western drift of south-east Asiatic peoples, superimposed upon a previous aboriginal Negroid stratum, and overlaid by a later wave of Alpine peoples."

ANTHROPOLOGY OF NORTHERN CHINA. By Shirokogoroff (S. M.)—*J. N. China Br. R. Asiatic Soc.*, Extra Volume II, Shanghai, 1923. 127 pp., numerous tables and graphs; one summary map.

Under this somewhat general title the author has discussed the results of his anthropometric measurements on 396 northern Chinese from Chihli, Shantung and Manchuria, in comparison with those on limited groups of Manchus and Koreans. The principal purpose of the work as stated in the preface is "to offer a summary description of the physical characteristics of the Chinese and to discuss the constituent types."

While admitting the limitations imposed by the relatively small numbers comprising his series, the author has thoroughly analyzed his data by the methods of interserial differences and correlation. It is expressly stated however, in the summary "that the differentiation of the Chinese cannot be based on a preliminary limited number of measurements and indices." From the standpoint of physical anthropology the following general conclusions are of interest though they are not wholly new:—

"The absolute measurements of the Chinese correlate each other. The stature and the head breadth are the fundamental characters that determine other absolute measurements, except nasal, frontal and ear characteristics."

"The relative measurements follow the same regularity as the absolute measurements."

"From an anthropological point of view the Chinese are a complex of different anthropological types, which may be distinguished in an amalgamated state among the Chinese."

A useful appendix of 14 tables is attached giving the average, maxima and minima of both absolute and relative measurements for the Chinese groups, for the Manchus and Koreans and for a series of Dahurs comprising 49 males from Heilungkiang. It is unfortunate that in the body of his text the author has not consistently given all the results of his absolute measurements in one scale, either millimetres or centimetres, and that numerous numerical errors have remained uncorrected.

DAVIDSON BLACK

ON THE NATIVE TRIBES OF YUNAN. By Ting (C. K.)—*Proc. Anat. & Anthrop. Soc. of China*, Peking, 1920–21, 5 pp.

Although foremost a geologist, Dr. Ting is taking a keen and direct interest in anthropological work on his people. In this paper he gives us modifications of Major Davis' classification of the languages of the Yunan, and also a series of measurements on some of the tribes of this territory belonging to the Lolo family. The Lolos who, as well known, are not Chinese, are shown to be dolichocephalic.

ARGONAUTS OF THE WESTERN PACIFIC. By Malinowski (Bronislaw)—8°, London (George Routledge & Sons; New York, E. P. Dutton & Co. $8), 527 pp., 5 maps, 67 illstr's.

A handsome book with excellent illustrations, devoted especially to "an account of native enterprise and adventure in the archipelagos of Melanesian New Guinea." As a matter of fact the work is a high class contribution to the ethnology (habits, customs, etc.) of the people to whom it extends, particularly the Kulas of Eastern New Guinea.

So far as Physical Anthropology is concerned the data are regrettably meagre, but there are observations on racial conditions and on the general appearance of the men and women of the various tribes, with many direct or indirect notes on their mentality.

The book is much above the level of ordinary accounts of travellers and must prove quite indispensable for the ethnologist interested in these regions.

A CONTRIBUTION TO TONGAN SOMATOLOGY. By Sullivan (Louis R.)—*Mem. Bishop Mus.*, VIII, No. 4, Honolulu, 1922 (Bayard Dominick Exp. Publ. 2), 233–'60, 4 pl.

The paper gives the results of measurements and observations on 121 males and 104 females (184 adults). The conclusions are that in general the Tongans show characteristics which approximate them to the Yellow-Brown rather than the White race. There are evidences of some Melanesian admixture, more so than in the Samoans, and as a group the Tongans show also "noticeably more variation than the Samoans;" nevertheless "in their broader racial affinities the Samoans and Tongans are very similar." The author believes in the feasibility of separating the yellow-browns into a yellow and brown component; in actual experience he will find this is quite impossible if we compare similar social and environmental classes of these peoples.

MARQUESAN SOMATOLOGY WITH COMPARATIVE NOTES ON SAMOA AND TONGA. By Sullivan (Louis R.)—*Mem. Bernice P. Bishop Mus.*, IX, No. 2. (Bayard Dominick Expedition, No. 6), Honolulu, 1923.

"The modern 'Polynesians' of the Marquesas Samoa and Tonga, are a mixed people. This fact accounts for the great diversity of opinion regarding their racial origins and affinities. In addition to the Polynesian population there is a second type resembling the Indonesian peoples of Malaysia, and a third extremely short-headed element. This paper deals mainly with the Polynesian and Indonesian types. The unrecognized presence of the Indonesian type has given rise to the theories of Indonesian affinities of the Polynesian peoples.

"When the Indonesian element is removed, the Polynesian is more strikingly Caucasoid. Some of the Caucasoid traits of the Polynesians may be due to the presence of a third type not yet isolated. At present it seems best to regard the Polynesian type as an offshoot of the primitive Mongoloid stem, very close to where some Caucasians branched off.

"The Indonesian type is usually regarded as Mongoloid also but is strongly divergent in the direction of the Negro. The resulting hybrid of the Polynesian and Indonesian types is much more Mongoloid in appearance than is either of the parental types.

"The Polynesian and Indonesian types cannot be considered as close relatives in a physical sense. Indeed, their only claim for relationship is that both may be somewhat hesitatingly classed as divergent Mongols. But even if such a classification is eventually proved to be justified, the relationship is a very distant one.

"In the Marquesas are marked inter-island differences in the distribution of the two types. The Indonesian type is for the most part confined to the islands of Ua Huku, Nuku Hiva and Hiva Oa. In Tonga also the Indonesian element is much more concentrated in the northern island groups, Haapai and Vavau but especially in Haano. No certain inter-island differences were found in Samoa.

"These two types do not exhaust the possibility of finding other physical types in Polynesia. There is unmistakable evidence of Melanesian influence, particularly in Tonga. The Indonesian type has many Negroid characteristics, which have led to an exaggerated opinion as to the amount of Melanesian blood in Polynesia.

"In addition there is an extremely short-headed element in Polynesia, referred to by Dixon as Malayan; by Elliot-Smith as Proto-Armenoid; and by others as Indonesian or Alpine. Apparently it is this element of the population that Deniker refers to as Polynesian. At present its claim to distinction as a separate type seems to consist chiefly of extremely short heads, associated with narrow faces, narrow noses, light skin and well developed beard and body hair. As yet I have not been able to establish a sufficiently large group of associated characters to warrant its discussion. It seems probable however that this type may account for some of the Caucasoid traits of the Polynesians. This, as well as many other phases of the Polynesian problem, needs further study in the areas in which the people are more characteristic of this type."

THE ANDAMAN ISLANDERS. By Brown (A. R.)—8° (Cambridge [illegible]iversity Press), 504 pp., 2 maps, 19 plates.

This book, which contains some parts of the results of anthropological [illegible]search carried out in the Andaman Islands in the years 1906–1908, deals essentially with the social institution of the tribes of the Great Andaman. It has but little of practical interest to Physical Anthropology, but there are some very good portraits of the natives, and the Introduction gives valuable geodetical and climatic notes on the islands as well as some useful notes on their Negrito population. "The aborigines of the Andaman Islands have been in their present home for a great many centuries. It is not possible to say with any degree of certainty how or when they first reached the islands . . . The balance of probability is in favor of the view that the Andamans were peopled, either by sea or by land, from the region of Lower Burma." The Andamanese are probably "in physical character, in language and in culture, of the original Negrito race . . . Although of one race throughout, the Andaman Islanders are divided into several groups, with differences of language and culture. There are two main divisions, which will be spoken of as the Great Andaman Group and the Little Andaman Group respectively . . . The natives of the Great Andaman Group are divided into tribes of which there are ten, each with its own distinctive language or dialect and with a name." The total number of the natives of the Great Andaman Island in 1901 was counted as 625, while the total number of the Negrito on the rest of the islands was 1257. These numbers have of course no claim to absolute accuracy. "During the last fifty years the numbers of the Andamanese have been greatly diminished. This has been the result of the European occupation of the islands, and is chiefly due to new diseases that have been introduced amongst them." Together with the increased death rate there has been also a considerable decrease in the birth rate; "a birth is a rare occurrence, and of the children born very few survive infancy;" but "this decrease of population has not as yet affected the Little Andaman." In 1858 the Negrito population of the Andaman Group was still in the vicinity of 5,500.

ANTHROPOLOGICAL RESULTS OF THE DUTCH SCIENTIFIC CENTRAL NEW GUINEA EXPEDITION A° 1920. FOLLOWED BY AN ESSAY ON THE ANTHROPOLOGY OF THE PAPUANS. By Bijlmer (H. J. T.)—Leiden, 1922, roy. 8°, 95 pp., 4 pl., 3 maps.

An exceptionally good report on the anthropological work of an important Dutch expedition, with large bibliography and effective illustrations. The work relates especially to measurement and observations on the living, though 12 crania were also measured. The conclusions are, very briefly, that the existence of pure Negrito on the island is not yet proven. The highland tribes are short and more Negrito-like than the people of the coast, but the author regards them all as Papuans, whom however, he looks upon as three-quarters Negrito (the other quarter being probably Dravido-Veddaic).

The work is a contribution of permanent value to the still hazy anthropology of the great island and of the Papuans in general.

ANTHROPOLOGIE DER NEU-CALEDONIER UND LOYALTY-INSULANER. By Sarasin (Fritz)—4to, Berlin, 1916–1922, 651 pp; with fol. atlas of 64 plates.

This is the most important and best printed work that has yet appeared on the New-Caledonian and Loyalty Islands groups of the Melanesians, dealing with the physical anthropology of the living as well as the skeletal remains, and that the whole skeleton. It is a worthy follower of the large and valuable contributions by the brothers Sarasin to the natural history and anthropology of Ceylon (1887–1908), and Celebes (1898–1906), and to the three volumes on the zoölogy and botany of the Melanesian Expedition (1913–1921) by Fritz Sarasin and Jean Roux.

It is imposible to review in the available space the many points of interest brought out in this study. Among the more general conclusions are the following:

The New Caledonians with the Loyalty Islanders, and the latter in their three subdivisions, while all fundamentally related, are nevertheless to-day all distinct groups with greater or lesser differences. Even among the New Caledonians themselves there are evident some local varieties. These differences, in the author's opinion cannot be attributed to Polynesian admixture, as usually thought, though some admixture of this nature is probable. He is much more inclined to regard them as resulting from the natural variability of these human groups and as local developments in the islands.

As to the period of settlement of these islands by man, nothing is known as yet, but the probabilities are that this period is pretty remote—though not geologically ancient. There is also uncertainty as to whence these people came, but there are indications that this was from the not far distant north. The only admixture of consequence with foreign elements admitted by the author is that of the natives on Mare Island in the Loyalty group.

In a final chapter Dr. Sarasin gives his interesting views as to the position of the New Caledonians in mankind and as to their phylogeny in general.

It need only be added that like the Sarasin brothers' work on the "Veddas" and "Toalas," so the "Anthropology of the New Caledonians and Loyalty Islanders," will constitute one of our reliable works of reference.

COLONISATION ET ÉMIGRATION ALLEMANDES EN AMÉRIQUE. By Le Conte (R.)—*J. Soc. Américanistes*, Par., 1922, XIV n. s., 83–105.

A valuable historic account of the earlier colonization of the Germans in various parts of America.

U. S. WHITES

AMERICA'S RACE HERITAGE. By Burr (Clinton Stoddard)—12mo, N. Y. (The National Historical Society), 1922, 337 pp., 1 map, 28 illustr's.

The author of the book "is an average citizen of this Republic, who perceives that the American People are on the threshold of the greatest crisis in their history." The volume "is intended primarily as a study of the significant facts respecting the population of the nation." The writer's "motive is a wholly patriotic one," and the book is intended to reach the "influential elements that can bring pressure to bear on our lawmakers to save the United States in this great crisis." As a citizen therefore, he pleads to "be allowed to present to his countrymen in plain, unembellished language, the cardinal views derived from the researches of present-day anthropologists, historians, economists, sociologists and biologists." The book reposes considerably on Madison Grant, Lothrop Stoddard and authors of this class. It deals in a literal rather than scientific way with: Traditional America; the Old Immigrant Stock (Early Period); the Old Immigrant Stock (Modern Period); the new Immigrant Stock; the Racial Factor; the Colored Elements; Assimilation and Heredity; the Immigration Problem; the Exploiter and the Sentimentalist Refuted; the Racial Aspect; Nordic America; and Foreign Relations and World Welfare. It is another expression of inbred mental conservatism which here as elsewhere is liable to see things darker than they are. The conclusions are fairly simple: "To save America for Nordic humanity, it only needs a cessation of immigration." "It would take but two or three decades of emigration to scatter the majority of the some 8,000,000 Alpines and Mediterraneans to their homelands" from the memory of which they are hard to wean. The American "administration is pledged to devise a new restrictive immigration policy . . . It may be sooner than most people imagine that our incoming immigrants will be minutely examined by a corps of eugenics expects (experts?), who will make certain beyond the shadow of a doubt that we shall carry on the heritage left to us by our pioneer Nordic forefathers."

ANALYSIS OF AMERICA'S MODERN MELTING POT. By Laughlin (Harry H.)—*Congr. Doc.* Ser. 7-C, 8°, Wash., 1923, 724–831.

A sensible, serious, even if not scientifically fully adequate presentation of facts concerning the present showing of immigrants from various countries as to persons who become dependents, with indication of further steps for curbing the admission of abnormals. Acting since 1920 as an "expert eugenics agent" of the House Committee on Immigration, Dr. Laughlin collected extensive data on the proportion of the various components of the United States' people in institutions for dependents, feeble-minded, epileptics, insane, criminal, tuberculous and blind and deaf. The results show that in general there is a considerably higher proportion of immigrant "social inadequates" than would seem to be called for by their numbers in the population. The individual nationalities represented show, however, rather widely different quota of such persons, which creates a suspicion of a "dumping" process of the undesirables from some of the European countries. The author advises further strengthening of the requirements for admission, and that not only in examinations, but also in obtaining information on family conditions.

SOME OF THE CAUSAL FACTORS IN THE INCREASED HEIGHT OF COLLEGE WOMEN. By Mosher (Clelia D.)—*J. Am. Med. Ass.*, LXXXI, 1923, 535–538.

"American college women during the last three decades have increased in size. The studies made at Stanford University of 4,170 women students who entered during a period of thirty years show at the time of admission not only an increase in weight but also an increase of 1.2 inches in average height. These results have been confirmed by the Vassar College statistics based on the examinations of 7,064 women during 37 years, an investigation which shows an increase in height "well over 1.5 inches" and also by Smith College measurements of 10,149 women during a period of 22 years."

These young women show also increased weight and girth of waist. Causes—"The vigorous modern girl, physically fit, eats in season and out and is as hard to satisfy as a growing boy—and for the same reason. The body is working normally and needs more food for growth and development. Here we find a reasonable explanation of the fact that the woman not only functions more perfectly, but weighs more and is growing taller, while, as was demonstrated in 1917, the difference in muscular strength between men and women is due to the difference in use of muscles and not to sex."

AMERICAN INDIAN

An Amerind Type in China in T'ang Times. By Seligman (C. G.)—'Man," Aug. 1924, XXIV, No. 8, 113.

"The object of this note is to point out that in China we have objects dating from the T'ang dynasty, i. e. early mediaeval times, which so closely reproduce the facial characteristics of the American Indian, that the observer immediately thinks of the latter rather than of a Chinese."

The author, one of the foremost of English anthropologists, shows two specimens, one of which is a large clay whistle in the form of a head and the other a striking good-sized figurine, the Indian-like features of which are unmistakable.

Le Problème du peuplement initial de l'Amérique et de l'Origine Ethnique de sa Population Indigène. By Vignaud (Henry)—*J. Soc. Américanistes* Par., 1922, XIV n. s., 1–63.

The author (former President of the Société des Américanistes of Paris, now deceased), reaches among others the following conclusions:

The problem of the origin of the American Indians may already be regarded as settled in its essentials. There can no longer be any possible doubt that the Indians came from Northeastern Asia and that they formed a branch of the yellow-brown race. The exact epoch of the coming of the Indians cannot be determined, but it was probably not greatly anterior to historic times. It seems that another branch of the same race may have reached America over Europe, Greenland and Labrador. The Americas were peopled exclusively by the Asiatic yellow-browns and no other race has either preceded or followed them up to the advent of the Whites, though there may have been accidental contacts by small parties driven to the American shores.

These and the remainder of M. Vignaud's conclusions are (with the exception of the impossible accession over Europe and Greenland) identical with those given in Hrdlička's "Genesis of the American Indian" (*Proc. XIX Int. Cong. Americanists*, Wash., 1917, 559–568.)

American Indians, Tribes of the Prairies and the East. By Dengler (Hermann)—pp. VII, 1–80, 97 illustrations, (Albert & Charles Boni), New York, 1923, ($2.50).

The main object of this volume is "to illustrate the life of the Indians from the time they came into contact with white races up to the middle of the XIX century . . . The pictures have been selected from the old classical works about the Indians"—and it is a good, well reproduced selection provided with ample legends.

A tasteful production which cannot but be received kindly by all interested in the American Indian.

The Red Man in the United States. By Lindquist (G. E. E.), New York, 1923 (Geo. H. Doran Company), 461 pp.

This is not a book of scientific research, nor even a scientific compilation, but "an intimate study of the social, economic and religious life of the American Indian." The "Committee on Social and Religious Surveys" is responsible for the publication which, it is hoped, "may appeal not only to those who for special reasons are particularly interested in Indian affairs, but also to a considerable extent to the reading public" presenting as it does the present status and the future possibilities of the "original American." The book is divided into two parts, the first giving historical and ethnological generalities, while the second presents in geographical arrangement—the results of the surveys of the various reservations, though here too "every effort has been made to supply the necessary background of history and tradition." The whole effort is connected with Protestant missions.

THE CHEYENNE INDIANS, THEIR HISTORY AND WAYS OF LIFE. By Grinnell (George Bird)—New Haven, Yale University Press, 1923, 8°, 2 vols.

These well put up and well illustrated volumes deal with the general description and cultural life of the Cheyenne Indians. The scope of the work will best be seen from the contents: Early Cheyenne History; Old-Time Ways; Village Life; Certain Camp Customs; Social Organization; The Boy and the Girl; Woman and her Place; Women's Societies; Industries; Subsistence and Hunting; Games and Amusements; Tribal Government; War and its Ways; Warrior Societies; Religious Beliefs; Disease, Healing, Death; Useful Plants; Ceremonial; Medicine Lodge; Massaum Ceremony; The Culture Heroes; and Notes on Cheyenne Songs. An ample index at the end of the work facilitates reference. The illustrations as well as numerous items in the text are of interest to physical anthropology.

THIRTY-FOURTH ANNUAL ARCHAEOLOGICAL REPORT, (of the Provincial Museum, Toronto). 1923. By Orr (R. B.)—*App. to Rep. Minister Educ., Ontario.* Toronto, 1924.

The well printed report contains much of historical interest concerning the Indians of the great Province of Ontario. The portraits of natives and the following articles are also of interest to physical anthropology:

Orr (R. B.)—The Crees of New Ontario, 9–24;

Chief Long Lance—When the Crees moved west, 25–34;

Abbé Faillon—Indian Tribes on the St. Lawrence at the Time of the Arrival of the French, 82–88; and

Hammond (J. H.)—Exploration of Ossuary Burial of the Huron Nation, 95–102.

THE COPPER ESKIMOS. Part B: PHYSICAL CHARACTERISTICS OF THE COPPER ESKIMOS. By Jenness (D.). REPORT OF THE CANADIAN ARCTIC EXPEDITION 1913–'18. Volume XII: Ottawa, 1923 (F. A. Acland), 8°, 89 pp., 12 plates.

This report is based on the measurements of 82 "Copper," 2 Hudson Bay, 4 Mackenzie River and 14 Alaskan Eskimo males, with 44 "Copper" and 1 Mackenzie River Eskimo females. The measurements taken were those of stature, head length, breadth and circumference, facial lengths, lower and total, facial breadth, nose height, breadth and depth, and jaw breadth. Visual observations were made specially on the hair, forehead, eyes, nose, lips and ears.

The principal conclusions arrived at are: The Copper Eskimos show more resemblance to the eastern Eskimos than to the Alaskan. The Copper Eskimos differ from most other Eskimos in that the head is slightly longer and broader, although the cephalic index is virtually the same as among the pure-blood tribes to the eastward. There is no indication of European admixture among the Copper Eskimos, but a little evidence of slight Indian admixture. The report is accompanied by twelve plates of good portraits.

Osteology of the Western and Central Eskimos. By Cameron (John) with a Special Report upon the Teeth by S. G. Ritchie and J. S. Bagnall. Report of the Canadian Arctic Expedition, 1913–'18, Vol. XII, Part C; Ottawa, 1923 (F. A. Acland).

"A considerable number of osteological remains, gathered at different times and in various places, were brought back by the Southern party of the Canadian Arctic Expedition, and deposited in the Victoria Memorial Museum at Ottawa." They consisted of 30 Eskimo crania with a quantity of other parts of the skeleton, from various localities, principally Victoria Island, Port Clarence and Barter Island. The report on this material extends to 66 closely printed pages and is illustrated by 9 full page plates. Eleven male and fifteen female crania were available for study. The main features of these skulls were, the obtrusiveness of the zygomatic arches, the width of the external pterygoid plates, the shallowness of the glenoid fossae, the relatively large size of the superior maxillary and malar bones, and above all the marked reduction in the width of the nasal apertures. The average capacities of these crania were much below those of the Eskimo skulls in the Royal College of Surgeons Museum, a point that demands further investigation. The average nasal index was found to be low, namely 43.7. The orbital index was high in both sexes, thus betraying a Mongoloid affinity. The author's naso-orbito-alveolar index was applied to these crania and yielded a slight sexual difference, the averages being consistently higher in the female.

The evolution of the Eskimo type of skull is discussed at length. The author concludes that this is mainly due to two factors, namely, specialized mastication and climatic environment.

In the craniometric investigations three new indices were devised and utilized; the index of height of the bregma above the glabella-inion line, the index of height of the mandible in the molar region and the index of width of the mandibular ramus.

The limb bones of the collection had been so ravaged by wild animals that very few intact specimens were available for study.

In the report of the teeth the main facts elicited are the perfect dentition, the excessive wear of the teeth and their large size, particularly so in the molars.

THE TURNER GROUP OF EARTHWORKS, HAMILTON COUNTY, OHIO. By Willoughby (Charles C.), WITH NOTES ON THE SKELETAL REMAINS, by Hooton (Ernest A.)—*Papers Peab. Mus.*, Cambridge, 1922, VIII, No. 3; Phys. Anthrop., pp. 99–132.

A careful study of 35 somewhat fragmentary skeletons from the famous Turner group of mounds in Ohio. Unfortunately 12 of the skeletons were of intrusive character, so that the remaining series is but a small one. Of the author's well considered conclusions the following may be quoted: "It may be said positively that the people of the Turner Group show practically no physical affinities with the people who lived on the Madisonville site, beyond those which are common to all Indians. The affinities of the Turner Group people are rather with the Eastern dolichocephals, although there is present a brachycephalic element such as is often found also among the Eastern Indians. The Madisonville people were mostly brachycephalic and deformed, while the Turner Group people were mostly dolichocephalic and without cranial deformation. The Madisonville people had short broad faces and short broad noses; most of the Turner Group people seem to have had long narrow faces and long narrow noses. The muscular development of the Turner Mound people was superior to that of the Madisonville people, especially as regards the bones of the lower extremity, but the Madisonville males seem to have been slightly taller than those of the neighboring but older group."

American Anthropology would be greatly indebted to Professor Hooton, who has now for several years past been devoting himself to the study of the skeletal remains of the Ohio "moundbuilders" (see Vol. III, No. 4 of this JOURNAL), for an eventual critical somatological review of this whole important region.

LA ANTROPOLOGIA FISICA Y LA ANTROPOMETRIA EN MEXICO. By León (Nicolas)—*Anal. Mus. Nac. Mex.*, 1922, 99–136.

Good historical account of anthropological work in Mexico, with large bibliography. The article is practically the same as that published in 1919 in the *American Journal of Physical Anthropology* (II, No. 3), but is nicely supplemented by portraits of the principal workers in Mexican anthropology, and by illustrations showing the cranial and skeletal collections of the Museo Nacional before the revolution.

CONOCIMIENTO ANTROPOLÓGICO DE LAS AGRUPACIONES INDIGENAS DE MÉXICO. By Pauer (Paul Siliceo)—*Ethnos*, 2 ser., 1922–3, I, 15–35.

A useful brief résumé of actual somatological knowledge of the Mexican Indian, with bibliography.

Vom Roroima zum Orinoco. By Koch-Grünberg (Theodor)—8°, V, Stuttgart, 1923, 27 pp., map, 180 plates of portraits.

The portraits published in this volume are those of Indians encountered by the author in his voyage of 1911–'13 in a number of tribes of the Rio Branco and along the Orinoco. Regrettably no measurements were made on this journey.

The types here reproduced constitute in a way a continuation of the author's former "Indian types of the Amazon Region." The present volume is published with the aid of the Baessler Institute of Berlin. The types themselves resemble throughout the types of Indians of Northern America, excepting the more specialized ones of the Plains Indians.

BIOLOGY, ONTOGENY, VARIATION—GENERAL

Studies in Human Biology. By Pearl (Raymond)—Baltimore, 1924 (Williams & Wilkins Co. $8.00).

"The material brought together in this book represents what has been a major interest of the writer's scientific life for more than twenty years past . . . The major portion of this book has appeared before in the form of papers in various scientific journals" but "all of the old material has been carefully edited, and in some cases extensively revised." Chapters IX, XI, and XXV are new.

The book contains much material of value to anthropology. It is too full of information to permit in the space here available of abstraction; but parts of its contents have been dealt with in this Journal on other occasions. The contents are: The weight of the human brain; Intelligence and the size of the head; Race crossing and the sex ratio; The sex ratio among the Jews; Congenital malformations; Centering infant mortality; Mortality and evolution; The vitality of the peoples of America; Trends of vital indices; Constitution and tuberculosis; The influence of physical activity upon mortality; The longevity of the parents of the tuberculous and the cancerous; Comparing the mortality of man with that of other animals; National food consumption; Food waste; An index of the age distribution of a population; Some biological factors in the epidemiology of influenza; The incidence of influenza among the tuberculous; Epidemic encephalitis; The statistical evaluation of public health activities; The population problem; Biology and war; The stability of England's population growth; The curve of population growth; and The growth of human populations.

The printing and binding of the volume are well above the average.

Ueber die Altersschätzung bei Menschen. By Müller (L. R.)—Berlin, 1922, 62 pp. 87 illustr.

This well illustrated small book contains a welcome survey of all the factors used in estimating the age of man, especially of the living. New and old observations are brought together on teeth, their wearing down, and the changes in the gums; on the accumulation and shifting of subcutaneous fat; on the changes in skin color and wrinkle-formation; on hair, its loss, its occurrence in the outer ear opening, etc. Attention is called also to age changes in the eye, ear, mouth, hands, and sexual organs.

A. H. SCHULTZ.

THE FETUS

MORPHOMETRY OF THE HUMAN FETUS WITH SPECIAL REFERENCE TO THE OBSTETRIC MEASUREMENTS OF THE HEAD. By Calkins (L. A.)—*Am. J. Obst. & Gynec.*, 1922, IV, No. 2; repr. 24 pp.

Measurements of 450 fetuses lead the author to the following conclusions: "Measurements of the head . . . plotted as ordinates against standing heights as abscissae for any group of Caucasian fetuses, result in straight line curves (This is also true of measurements of other parts of the body). The relationship between any two dimensions can, then, be expressed by the straight-line empirical formula: $y=ax\pm b$, (x) and (y) being body dimensions, and (a) and (b) constants. By study of these formulae we find definite mathematical proof of development in the cephalocaudad direction during embryonic life and, a definite rate of growth in any dimension, established by the third month and maintained throughout the remainder of prenatal life. By the aid of these formulae, one may accurately construct the external body proportions of a fetus at any period of development, if given any single dimension. Likewise, one may deduce the size of the head if one can accurately determine any body measurement *in utero*. A definite technic for this indirect intra-uterine cephalometry is worthy of prolonged intensive study. By such a method one could solve problems of disproportion between passage and passenger, as well as determine viabilty and maturity with a considerable degree of accuracy. Birth moulding probably affects greater changes in head dimensions than ordinarily thought. Fetuses preserved in formalin by the method outlined, better represent the living fetus *in utero* than any other available type of material."

SIMPLE METHODS OF CORRELATING CROWN-RUMP AND CROWN-HEEL LENGTHS OF THE HUMAN FETUS. By Noback (G. H.)—*Anat. Rec.*, 1922, XXIII, No. 4, 241–244.

"Investigators in prenatal anatomy and development report their findings in one of three ways as regards length of the individuals studied. Some writers use both crown-rump and crown-heel length. Others use only the crown-rump, and some use the crown-heel alone. Work based on one of these measurements alone is obviously difficult to compare with work based upon the other." The author gives simple mathematical formulae for conversion of these measurements.

Development of the Auricle in the Human Embryo. By Streeter (George L.)—*Contrib. to Embryology*, Carnegie Inst. of Wash., 1922, XIV, No. 69, 111–138, 6 pl. 8 text-fig.

A very good paper on the subject, giving results of extensive original investigations. "The transition from the arrangement of typical branchial bars to an auricle of primitive type takes place during the period represented by embryos from 4 to 16 mm. . . . In the younger stages—for example, 85 mm.—the soft tissues of the auricle give the appearance of fulness and tend to be thrown into folds. These should not be confused with the longitudinal folds seen in the adult scapha of some of the long-eared animals. As the cartilage expands, the subcutaneous tissue becomes relatively more scant, particularly in the region of the anthelix and scapha-helix. The histological appearance of the crus helicis is quite different from the hyoid auricle (anthelix and scapha-helix). This difference consists chiefly in the presence of a great number of hair follicles and a considerable amount of subcutaneous fat. These are almost absent in the scapha-helix. The form of the concha, particularly of its articular portion (superior and inferior fossae and plica principalis), does not make itself conspicuous until after the fetus has reached a crown-rump length of 135 mm., although the complete outline of these parts can be recognized in the cartilage in embryos of less than 50 mm.

"If one studies a great many specimens, covering the period from 30 mm. to full term, it will be found that there is great variation, just as exists in the adult ear, and that the individuality of the ear is expressed early, as soon as the respective parts can be identified. The tragus may consist of a single lobe or may tend to be subdivided into two lobes; the form of the antitragus varies considerably, and still more does the lobule. The part that varies most, however, is the scapha-helix, particularly as regards its extent and the character of folding of the helix. The least variable is the articular portion, including the crus helicis, the two articular fossae, and the plica principalis." A bibliography of 25 items completes the article.

Beiträge zur Anatomie des fetalen Magens der Japaner. By Okamoto (Kikuo)—*Folia Anatomica Japonica*, Tokyo, 1923, I, No. 5, 251–272, 1 table, 2 pl.

Continuing his studies on the stomach in the Japanese, the author has made careful observations and measurements on the organ in 15 Japanese fetuses and reports here the interesting results. In location and form the organ is found to present conditions much (though not quite) like those reported by other investigators in Europeans. In view of the difficulties of utilizing other men's observations in such painstaking studies, it is to be hoped that in his future work the author himself will be able to carry out at least the most desirable racial comparisons.

Rozwej Wzrostu i Proporcji Ciala Plodow Ludzkich (The Growth and Proportions of Human Fetuses). By Reicher (Michal)—*Archiwum Nauk Antropologicznych*, Warsaw, 1924, II, No. 5.

A detailed and valuable report on careful measurements of 366 fetuses with a number of children after birth, made, under Professor Mall, in the Embryological Department of the Carnegie Institution at Baltimore. The main results are:

The rate of growth of the different parts of the fetus steadily decreases, being more rapid in the first than in the second half of its intra-uterine life.

The smallest differences in the regularity of growth are shown by the trunk. Delivery does not have any important influence on the rapidity of growth.

The development of the main proportions of the fetus invariably takes the form not of a straight line but of curves.

The changes in the development of the stature and of the limbs are to a certain extent analogical. They show a minimum at the beginning and at the end of the life of the fetus and a maximum in the middle. The changes in stature are influenced mostly by the length of the legs.

A period of relatively rapid growth of legs and arms corresponds to a slow growth of the trunk and reciprocally the inter-membral index decreases largely during the life of the fetus especially during the first half. The legs are shorter than the arms during the whole intra-uterine life.

Changes in the development of the sitting height are due mostly to changes in the length of the head and neck. No measurements were made on the head or face.

The Polish text (82 pp.) gives the details.

FETUSES OF THE GUIANA HOWLING MONKEY. By Schultz (Adolph H.)—*Zoologica*, III, No. 12 (*Trop. Res. Stan. Contrib.* No. 106), 242–262. Pub. by *Soc. Zool. Park*, N. Y., Dec. 1921.

An examination of a series of fetuses of the Guiana howlers showed that "most of the typical differences existing between adult man and adult Alouatta—be it those of outer form or those of the skeleton—are already well defined in fetal stages, although not as yet as pronounced as in the adult."

THE CHILD

THE DEVELOPMENTAL TOPOGRAPHY OF THE LARYNX, TRACHEA AND LUNGS IN THE FETUS, NEW BORN, INFANT AND CHILD. By Noback (G. J.)—*Am. J. Diseases of Children*, Dec. 1923, XXVI, 515–533. Repr. Chicago, 1923.

"The descent of the respiratory system in relation to the vertebral column during childhood is not peculiar to this period in the development of the individual. It is merely a stage in a process which is already manifested in early fetal life and which continues to operate through infancy, childhood and maturity.

"The larynx: During fetal life, the topography of the epiglottis shows practically no change. It remains quite constantly opposite the first cervical vertebra. This level persists through infancy and childhood until puberty, when the adult relationship is attained, i. e. it lies opposite the third cervical vertebra.

"The inferior margin of the cricoid cartilage and therefore the lower limit of the larynx, descends during the course of prenatal life from opposite the third to opposite the fourth cervical vertebra, a distance represented by one vertebra and intervertebral disk. During infancy, this relationship remains constant; but during later childhood, another descent to the level of the sixth cervical vertebra takes place, a drop of two vertebrae and one disk. With the attainment of maturity, a further descent of one vertebra and disk has occurred, so that the inferior limit of the larynx is then opposite the seventh cervical vertebra.

"The bifurcation of the trachea: The tracheal bifurcation undergoes a descent caudalward in relation to the vertebral column during fetal life. It drops from opposite the third to opposite the fourth thoracic vertebra, a descent of one vertebra and disk. The natal relationship persists during infancy, but in childhood another descent takes place, and by puberty the bifurcation is opposite an area between the fourth and fifth thoracic vertebrae. This level is then maintained, apparently, through adult life.

"Topography of the lungs: The apices of the lungs remain at practically the same level as the suprasternal notch throughout the course of fetal life. The upper poles of the lungs in relation to the vertebral column undergo a slight descent during prenatal life from a level opposite the seventh cervical or first thoracic vertebra to the upper margin of the second thoracic vertebra, a distance of one vertebra or less. This level is apparently maintained throughout the course of postnatal life.

"The inferior margins of the lungs during fetal life undergo a descent from between the ninth and tenth to opposite the tenth or twelfth thoracic vertebrae, a distance equivalent to slightly more than one vertebra and disk. The latter level, present at birth, coincides quite closely to the levels as given in the standard texts and atlases for the adult, thus indicating the probabilty that the postnatal growth in length of the lungs is closely correlated with the increase in length of the thorax.

"The lobes of the left lung in the human fetus do not vary much from the condition in the adult, there being but 5.8 per cent of the total with atypical lobation. The lobes of the right lung depart quite markedly from the conditions usually described in the adult, there being but 36.8 per cent of the total with the typical three-lobed condition.

"The depth of the cardiac notch. The extent of the cardiac notch during prenatal life is extremely variable in a group of cases of the same body length. There is, however, a general increase in depth with increase in total body length."

Physical Development of Children and Young People During the Age of 7 to 18–20 Years. By Schiotz (Carl)—(*Videnskapsselskapets Skrifter*, I, Mat.-Naturv. Klasse, 1923, No. 4). Repr., 8°, Christiania, 1923, 54 pp.

A good piece of anthropometric work on 28,700 pupils of the public and higher schools in Christiania. The investigations extend to the following characteristics: Height of the body; Weight; Periods of development and puberty.

For the many interesting results, which regrettably are not summarized, the reader must be referred to the original which is printed in English. The numerous curves are too reduced to be of much utility, nevertheless some of them are of considerable interest. As natural the author finds important differences in both height and weight between the children of the poor and the well-to-do classes.

THE NUTRITION AND CARE OF CHILDREN IN A MOUNTAIN COUNTY OF KENTUCKY. By Roberts (Lydia)—*Childrens Bur. Publ.* No. 110, Wash., 1922.

The more or less backward state of the "mountaineers" of southern Kentucky and the Alleghanies in general is well known. "This study of a small mountain section of Kentucky included 123 families in which lived 256 children from 2 to 11 years of age. The heads of households in 103 families were farmers, but only 59 were occupied in farming alone, while 44 supplemented work on their farms by some other occupation. A total of 149 children were given physical examinations. Half this number had enlarged or diseased tonsils; more than a fourth showed symptoms of adenoids; over three-fourths had carious teeth. Only 7 per cent of the children were ranked excellent in nutrition; 18 per cent good; 35 per cent fair; 34 per cent poor; and 6 per cent very poor."

PHYSICAL FACTORS IN PREDICTING THE BASAL METABOLISM OF GIRLS. By Benedict (Francis G.)—*Proc. Am. Philos. Soc.*, LXIII, 1924, No. 1, 25–56.

"Based upon an analysis of the Nutrition Laboratory series of measurements of infants, young children, Girl Scouts and adult women, it is found that a most important factor correlating with basal metabolism measurements is height. The importance of introducing some index of the state of nutrition, such as Pirquet's pelidisi, and the fact that the total 24-hour basal heat production divided by the pelidisi referred to height shows a straight line relationship from 3 months to adult life further justifies the emphasis laid upon the height element in basal metabolism predictions. For new-born infants, both males and females, from 1½ to 6 days old it is recommended that the formula involving length, previously published by Benedict and Talbot, be employed in predicting the metabolism. For girls from 1 week to 12 years of age a new method or prediction involving height alone is recommended. From 12 to 20 years of age the metabolism of girls may at present be best predicted from the curve based upon a series of experiments with Girl Scouts showing the heat production per kilogram of body weight per 24 hours referred to age. For adult women 21 years and over the formula of Harris and Benedict for women, involving age, weight and height is retained."

HEAD. SKULL

HEREDITY OF HEAD FORM. By Schreiner (Alette)—*Genetica*, 1924, V, 385–454.

The question is raised whether the index-groups denoted as dolicho-, meso- and brachycephalic are head-types which are dependent upon a single pair of genes, or whether the index in each case is the result of the action of multiple factors. An analysis of the data published by *Bryn*, *Jorgensen* and *Frets* makes it very probable that both the largest length and breadth of the head as well as the total size of the head, are the results of the action of several independent genes and that, moreover, non-genetic modifications are to a large extent also acting. In different breeds of dogs the complex nature of the form of the head seems certain from the experiments by *Pearson*, *Nettleship* and *Usher*. The investigation carried out by the author includes 46 human families, the largest family covering 4 generations with 48 individuals. In estimating the dimensions of the head the length of the body was also considered. It was found that the geno-typical basis of the different head-types doubtless is rather complex, so that the measuring of the main indices is an inefficient method for the genetical analysis. The statistical method also fails entirely. It is therefore necessary in each case to get an exact diagnosis of the single morphological features dealt with and to trace them singly within large families through several generations. It is also necessary to pay attention to different non-genetic causes which may influence the early development of the head and the brain.

In accordance with *Toldt* it is suggested that the form of the head may depend upon two different categories of genes, one (the primary factors) influencing the form of the chondrocranium, the other (the secondary factors) affecting the later growth of the skull. To these may be added a third category of genes which influence the early de-development of the brain-hemispheres. Based on her personal investigations the author regards it as probable that the original form of the chondrocranium is a character dependent upon a single gene, and that to this extent one may speak of primary (or genuine) dolicho- or brachycephalic races. But this basal form does frequently not express itself in the cephalic index, since the other genes mentioned as well as the non-genetic modifications also influence the final result.

A. S.

VZRÚST NEUROKRANIA ŠKOLNÉ MLÁDEŽE ČESKÉ (GROWTH OF HEAD IN CZECH YOUTH. In Czech)—By Řehák (Julius)—*Anthropologie*, Prague, 1923, I, No. 4, 284–297.

The study is based on the head measurements of 1488 Czech boys, most of them born in Prague. It shows that there are perceptible differences in the increase with growth of the three main head diameters. The length was found to increase most between the sixth and eighth years, less between the eighth and eleventh years and somewhat more again between the twelfth and fourteenth years (puberty); the breadth increased most between the twelfth and fourteenth years, next between the sixth and eighth and last, as with length from the ninth to eleventh years; the height, similarly to length, was found to grow most between the sixth and eighth year and then more slowly. The *circumference* of the head enlarges most between twelve and fourteen, next between six and eight, least from the ninth to the eleventh year. It is remarkable that the growth in all the head diameters is slowest at about the tenth year, but this is in accord with the slowest growth in other parts of the body at this period.

The *cephalic index* decreased during the growth of the head, the length growing slightly faster than its breadth. The Czech children are highly brachycephalic.

ON STABILITY OF THE CEPHALIC INDICES WITHIN THE RACE. By Pearson (Karl) and L. H. C. Tippett.—*Biometrika*, 1924, XVI, Parts I & II, 118–138.

An important article in which the authors discuss the views of Boas and others on changes in head shape in childhood. Their conclusions are as follows:

"Dealing with a large amount of data we are unable to find any change of real significance in the cephalic indices for school children from 5 to 20. It may be taken as reasonably certain that at least from 8 to 20 there is no significant change in the shape of the head. The indices might be equally well determined from children of 10 or 15 or from adolescents of 20.

Dealing with Galton's material ranging from age 6 to age 80, we find again no evidence of a continuous change. The erratic values in extreme childhood and extreme age are largely due to means based upon inadequate numbers.

We seem therefore justified when dealing anthropometrically with the shape of the head as determined by the two cephalic indices in neglecting any correction whatever for age. We do not think that the confidence of anthropologists in the cephalic indices need be shaken by Miss Fleming's results.

From Table XI we see how remarkably stable is the cephalic index when we pass from one class of the community to a second, notwithstanding the great diversity of environment involved when we pass from the children of the professional classes to habitual criminals.

The stability of the cephalic indices in this country is then investigated from the standpoint of hybridisation. Our population had originally undoubtedly a mixed racial origin. In the various components there was just as undoubtedly a close association of head shape and pigmentation. If the race were still a mixture of these components, we should undoubtedly expect to find cephalic index correlated with hair and eye colour. Our investigation of the children of the professional classes shows no such association; we do not find dolichocephaly associated with a light pigmentation, or brachycephaly with a dark pigmentation. The conclusions we would draw from this is that the English people, whatever its original components may have been, is now thoroughly hybridised and indeed may venture to call itself a "race" as distinguished from the American population which is at present only a mixture of races. Those who will study the pedigree of individuals of the professional and upper classes—say, those of Sir Francis Galton, Charles Darwin or Sir Thomas Browne—will be surprised to find how very rapidly as we ascend in ancestry the ancestors are scattered over the whole face of this country, even from parts which 800 to 1000 years ago must have had different racial populations.

Having regard to the fact that extraordinary environmental differences in this country appear to make no significant change in the shape of the head, it is very difficult to accept Professor Boas' view that the child born of Jewish parents in Europe differs in head shape from the child born to the same parents after their arrival in America. The cephalic index of the Jews is much the same in the most diverse environments in Europe, and we do not believe that anything but hybridisation, or long selective action, can change the type, or make the Jew born in America akin to the European population there.

THE FREQUENCY AND DISTRIBUTION OF SOME ANATOMICAL VARIATIONS IN AMERICAN CRANIA. By Sullivan (Louis R.)—*Anthrop. Papers, Am. Mus. Nat. Hist.*, 1922, XXIII, pt. 5, 207–258.

The paper brings welcome observations on the frequency in (collectively) over two thousand Indian and Eskimo crania of the following conditions: Differences in the pattern of the lower second molar teeth; The apertura pyriformis; the arrangement of the sutures in the region of the pterion; the fossa pharyngea; the perforation or dehiscence of the tympanic element of the temporal bone; metopism; the inca bone; sutural or wormian bones in the lambdoidal suture; other sutural bones, mastoid division. The results are summarized thus: "The material at hand indicates clearly that the so-called European or Caucasoid peoples are uniform in having a high percentage of cusp reduction in the lower second molar. Four cusps is the rule. Next in order of cusp reduction are the negroid groups and the yellow division of the mongoloid race. The Australian and the brown division of the mongoloid race (American Indians, Malays and Indonesians) have a low frequency of cusp reduction. Five lower molar cusps is the rule . . . Considering first the frequecy of a frontal process on the temporal bone, we get a point of high frequency in the material from the Chullpa in the vicinity of Sicasica (Takana, Tama, Tam, Belen and Kupa Pukio). This peak dwindles down in the material from the ruins of Lake Titicaca and the Peninsula of Huata, yet is of greater frequency here than in the other groups studied. There is a minor mode of considerable frequency in California and Mexico and one North Pacific tribe, the Koskimo, also shows this characteristic quite frequently. The high frequency of epipteric bones, lambdoidal sutural bones, and metopism show a similar distribution for the major modes. In the case of the epipteric bones there is again a minor mode of high frequency in Mexico and the North Pacific area. While these three characteristics have the same general distribution there is little or no individual correlation of them. It is rather an exception to find them all or any two of them in the same individual. Such cases as do occur are no more numerous than would be expected on the law of chance.

The perforated tympanum has the reverse distribution. It reaches its greatest frequency in the material from the ruins near Lake Titicaca and dwindles down towards Sicasica on the one hand and Charassani on the other.

The pharyngeal fossa has its area of greatest frequency in Utah and in that part of Mexico inhabited by the Uto-Aztecan peoples.

The inca bone is most frequent in the North Pacific Coast area among the Kwakiutl and Salish people. A minor peak of high frequency exists in the material from coastal Peru, the Marañon country, and Sillustani.

The infantile type of the lower border of the apertura pyriformis prevails in the American Indian as a group as it does also in mongoloid peoples generally. It persists most frequently in the material from Utah designated as 'Basket Maker,' in the Eskimo, the Indians from Oregon and Cachilaya, Peru.

The anthropine or distinctly human type of apertura pyriformis has arisen in several areas in America. The principal points of high frequency in the groups studied were the San Simon, Tlanepantla and Tarascan material from Mexico, another in the material from the Island of Titicaca, diminishing in frequency north and south towards Charassani and Sicasica, respectively, and the more or less isolated series (so far as my material is concerned) from May's Lick, Kentucky.

The prenasal fossae were not of very great frequency in any group, yet were most common in the North Pacific Coast material, notably that from Kwakiutl, Salish, Haida and Chinook groups and from those Southwestern groups in which we found a high frequency of the pharyngeal fossa: Basket Makers, San Simon, Huichol, Cora and Tlanepantla groups.

In general, the distribution of the above-mentioned characteristics may be said to be as follows. The points of greatest frequency occur in groups located for the most part in close proximity to each other. The farther away from the mode we move geographically the lower the frequency. In a few instances we have minor modes in areas well removed from the point of the major mode geographically.

Our interpretation of this distribution will hinge somewhat upon our conception of the American Indian. I believe that the greater number of anthropologists who have studied the American Indian tribes agree that they all belong to the same race of mankind and that a majority of their fundamental characteristics are unquestionably mongoloid. They have in common coarse lank black hair, a yellowish brown skin, dark brown eyes, a poor development of hair upon the face, body and limbs, rather wide and massive faces, an intermediate nasal development and concave shovel-shaped upper incisors. But going beyond these similarities we encounter quite a range of variability in several characters."

The report is supplemented by a brief review of main anthropometric data on the Indians.

THE EFFECT OF MACERATION AND DRYING UPON THE LINEAR DIMENSIONS OF THE GREEN SKULL. By Todd (T. Wingate)—*J. Anat.*, LVII, Part 4, July 1923, 336–356.

"Shrinkage of the several dimensions of the cranium consequent upon transformation from the green to the dry macerated state bears no constant relation to the particular dimension. Great individual variation occurs and the percentage shrinkage, relatively small for length, increases somewhat for breadth and auricular height. On the average of all dimensions the shrinkage amounts to about 1.1 per cent of the final dried measurement.

The duration of measurable shrinkage in a normal summer atmosphere is about three weeks. Shrinkage certainly continues beyond this time but it is most clearly demonstrable by a shifting of the Euryon, fluctuation of the location of which may continue for three months. Shrinkage is naturally greatest during the first week of drying. Changes in temperature and humidity do affect the reduction temporarily and may even result in slight fleeting increases in dimension.

Of the factors which might be invoked as influencing shrinkage directly or indirectly we are able to eliminate sex, stock, age, cranial thickness, cranial shape and condition of sutures.

Of the characteristics of shrinkage three stand out fairly plainly. Shrinkage in the several dimensions is roughly compensatory. It is symmetrical. There is an actual play of the bones (or of the parts of bones) the one upon another during shrinkage, a play which is shown by the shifting in position of the Euryon, does not result in warping, and is independent of the condition of the sutures.

At the moment we have no data upon other bones which may be used for comparison with cranial shrinkage but this defect will presently be remedied.

In passing through the stage of maceration and during the first few hours thereafter the green skull loses a total average of 0.84 mm. in length, breadth and auricular height. This loss probably occurs during the first few hours of drying.

The average reduction in dimensions in transformation from the green to the dry macerated condition is the following: Length 1.8 mm. Breadth 2.1 mm. Auricular height 1.7 mm. Total 5.6 mm.

This shrinkage corresponds to a reduction of about 42 c.c. in a cranium of some 1500 c.c. capacity.

Given the linear dimensions in green and dry macerated states it is possible to calculate the shrinkage in capacity and the result will be accurate within a very few cubic centimeters, any discrepancy being due to variation in the dura volume. Further the accuracy of calculation of shrinkage is independent of the accuracy in calculation of actual capacity.

MAN'S NASAL INDEX IN RELATION TO CERTAIN CLIMATIC CONDITIONS. By Thomson (Arthur) and L. H. Dudley Buxton—*J. R. Anthrop. Inst.*, Jan.–June 1923, LIII, 92–122, 1 pl. (repr.).

The evidence gathered by the authors leads them to believe "that a platyrrhine nasal index is asosciated with a hot moist climate, and a leptorrhine nasal index with a cold dry climate, the intermediate conditions being associated with hot dry and cold moist climates. There is a positive correlation both on living males and on crania between the nasal index and the temperature. On living males there is also a postiive correlation between the nasal index and relative humidity. On crania this correlation although present, is small." In order to test these results the authors have calculated reconstruction formulae whereby from a knowledge of temperature and humidity the nasal index on the living or on crania can be calculated and compared with actual observations. Attention is also drawn to the correlation between nasal indices on the living and on crania. Finally, the authors suggest the possible application of conclusions arrived at on modern peoples to the study of the prehistoric inhabitants of Europe, and to the problem of migrations.

THE PROBLEM OF ORTHOGNATHISM. By Bolk (L.)—*Proc. Koninkl. Akad. v. Wetenschappen te Amsterdam*, XXV, Nos. 7 & 8. Repr. 8°, 10 pp.

The author is of the opinion that "the typically somatic human features are of a special character, viz. they are persisting fetal properties and conditions." He frequently "referred this fact to the influence of the endocrin system, which, through its inhibitive action, fixes fetal morphogenetic relations. The character of the human body, therefore, is its fetality, and this character results from what I am inclined to term a process of fetalization."

He then presents evidence from which "it is sufficiently evident that the orthognathous skull of man is to be considered as a persisting early fetal form. In stating this fact we have at the same time disproved the current opinion, that the sphenoidal angle, which is so characteristic of the human skull, is due to the intense development of the human brain. This angle, indeed, is not only a feature of all fetal mammalian skulls, but it occurs even in the chondrocranium of Reptiles. It is an essential character of, let me say, the primordial cranium of vertebrates in general."

DECLINATION OF THE PARS BASILARIS IN NORMAL AND IN ARTIFICIALLY DEFORMED SKULLS. By Oetteking (Bruno)—*Indian Notes and Monographs* (Mus. Am. Indian), 1924, No. 27, 25 pp.

"The declination of the pars basilaris in the normal skulls from San Miguel Island and in the artificially deformed skulls of the Chinook is greater than in Europeans. In the Chinook, the declination of the pars basilaris is distinctly influenced by deformation. Like the pars basilaris declination, the deformation affects also the cranial basis and the foramen magnum declination, *i. e.* its anterior fixed point, while the posterior one, the opisthion, is pushed upward by a special deforming device. No unequivocal correlations obtain in the two series either between the pars basilaris declination and that of the foramen magnum, or between the first and the three profile angles."

SKULLS: RACIAL

Catalogue of Human Crania in the United States National Museum Collections. By Hrdlička (Aleš)—*Proc. U. S. Nat. Museum,* LXIII, Art. 12, 1–51; Repr. No. 2480, Govt. Print. Office, Washington, D. C., 1924.[1]

"The collections of the Division of Physical Anthropology in the United States National Museum, begun, through the instrumentality largely of Dr. W. H. Holmes 22 years ago by the return or transfer of 2,300 crania from the Army Medical Museum, have now reached such proportions that their complete scientific description will take not merely years but generations. They embrace upward of 10,000 crania and skeletons, besides large quantities of various individual bones, and new accessions are still being received. The material is well identified as to people and locality, all specimens with imperfect information in these respects having been weeded out. The bulk of it is American, both north and south; but there are also fine series from Hawaii, Egypt and other regions.

It is plain that in the interests of science the principal data on this important material should be placed in the hands of scientific workers as soon as possible. If this cannot be in full elaboration it should be done in some simpler form. What anthropology needs most are ample, dependable data, which may with full confidence be used in investigation.

The simplest; most practicable, least costly way of achieving this is doubtless by means of a catalogue of the essential measurements of the specimens . . . The desirability of publishing a catalogue of the crania in the National Museum has long been felt by the writer, especially during the last few years, when time and again serious errors have been encountered in the writings of foreign authors dealing with American anthropology, obviously due to the fact that these authors lacked sufficient records on American skeletal material. In the course of years, also, there have accumulated many series of measurements for which individually there was and is little chance of publication . . . The catalogue will be published as parts of the Proceedings of the United States National Museum. Each part will be published and distributed as a separate and it is expected at least one of these separates will appear each year.

The arrangement of the catalogue will in the main be geographical, beginning with the northernmost parts of North America and proceeding southward, but due attention will be paid to already established groupings."

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[1] The "Catalogue" is printed also in a limited number of separates for free distribution to professional workers in and institutes of Physical Anthropology. Address applications to: U. S. National Museum, Washington, D. C., U. S. A.

The measurements, restricted to normal undeformed skulls comprise: Length, breadth and height of the vault; the two heights (total and upper) and breadth of the face; the height and breadth of orbits and of nose.

The first instalment of the catalogue contains the measurements of 412 Eskimo, 53 Aleut, 32 Tlingit, Haida and Athapascans, 25 Apache and Lipans, 187 Mongol and 33 Buriat crania; total, 742 skulls.

Altslavische Schädel von der Kaiserburg in Eger. By Szombathy (Josef)—*Sitzb. Anthrop. Ges.* Wien, 1921–2, 20.

In confirmation of the observations of Matiegka and others that the cranial type in central Europe has changed markedly since earlier historic times and that in the direction of brachycephaly which is very prevalent to-day, a collection of 28 well identified Slav skulls from Cheb (Eger), Bohemia, dating from the last third of the XII century, show still 43 per cent of dolicho-, 39 per cent of meso- and but 18 per cent of brachycephaly.

A Note on Bushman Craniology. By Shrubsall (F. C.)—*Man*, Dec. 1922, XXII, No. 12, 185–'7.

A brief report and discussion on additional valuable series of Bushmen and Hottentot crania. The Hottentot skull, while not far apart, is longer, narrower, higher and more prognathous than that of the Bushmen.

TEETH

Dental Anatomy. By Dewey (Martin)—St. Louis, 1920 (C. V. Mosby Co., $3.00).

The book "is presented with the hope that it will be found valuable to those interested in the study of dental anatomy, and especially teachers in dental schools and members of the dental profession." It is a well printed and profusely illustrated volume which well fulfills its purpose. Of interest to anthropology is the chapter on Measurements of Teeth, and average with minimum and maximum values of the measurements of all the teeth. The method followed is the well known standard method of Black. Other features of interest are the series of illustrations showing variation in the pulp cavities (from specimens of Dr. Richard H. Reithnüller) and the good radiographs (Dr. George F. Moffatt's specimens). What the anthropologist misses are high class photographs of teeth and especially more attention to normal tooth variability; but perhaps the time is not quite ripe as yet for an effective presentation of the latter subject.

Comparative Dental Anatomy. By Thompson (Alton H.)—St. Louis, 1922, 2nd ed., revised by Martin Dewey. (C. V. Mosby Co., $2.25.)

This handsomely printed and illustrated little book brings in readily assimilable form the morphological essentials about the teeth of animals and man. There are nine chapters: General Zoology and Comparative Anatomy; The Teeth in General; The Teeth of Invertebrates; The Teeth of Vertebrates; The Teeth of Fishes; The Teeth of Reptiles; The Teeth of Mammals (two chapters); and The Teeth of Higher Apes and Man; with Glossary and Index.

The work is a textbook and book of reference for dental students and dentists, not a record of research. The part of interest to anthropology is that dealing with the teeth of the Primates and this includes items which regrettably are subject to criticism. On p. 63 we read: "In the higher Apes the premolars are of the same form as in man, but are coarser and larger." This is only approximately true for the upper and lower posterior premolars of the anthropoid apes, while the anterior lower premolars differ considerably from those of man. On p. 78 there are the following statements: "In the animals which have long cusps, the glenoid fossa is decidedly concave, and in those in which the cusp is short the glenoid fossa is only slightly concave and often entirely flat. When we find the cusps of the teeth so arranged that the tooth has a long antero-posterior diameter the condyle has a great bucco-lingual diameter. The greatest diameter of the tooth is always the opposite to the greatest diameter of the condyle." Most of this lacks substantiation. In man alone the depth of the fossa differs considerably. On p. 183 in connection with the statements concerning premolars there is again no mention of the important differences that exist between the anterior lower premolar of the apes and of man. The molar teeth of the apes are described as "square and coarse," which is incorrect or only partly correct; and exception must be taken to some parts of the following statements: Thus, it is not true to say that "In man no one tooth surpasses another in height but all are on the same level," for it is well known that the unworn, fully erupted canines are frequently if not generally slightly to very perceptibly higher than the rest of the teeth. Similar objections may be made to Sections (f) and (i) on the same and the following pages—the statements are only partly correct and there are other errors.

In the section on "The Teeth of Man" (p. 191) there are found some excellent statements but others are not quite satisfactory. Thus the occasional molars with four or three tubercles are regarded as primitive forms; the fifth cusp of the second lower molar is wanting "in the higher races though often present in the lower;" the bicuspids of early man "were large and thick and of large size in proportion to the molars" (p. 195); in the Australians "the jaws are massive, with a monkey-like squareness in front" (p. 197); "in the New Caledonians and some other Australoid people the central incisors are so large and insectivorous-like as to show their form through the lips;" "The Negroid races have teeth that are large, thick, dark-colored, coarse and ape-like and project forward" (*ibid.*); "Some of the Polynesian negroes have small arches, with small finely formed teeth" (p. 199); "The Mongoloid races have the jaws rounded in relation to the brachycephalic skull" (*ibid.*); "The teeth of the Japanese are similar to the Chinese, but smaller, as the race is small-boned" p. 200; "The Eskimos have rather small teeth" (p. 200); The Mound-builders had teeth that "were large, yellow and squarely set and coarsely made;" "The ancient Aztecs had small arches and small, fine teeth;" etc. etc.

It is a pity that this book which, if free from errors, would make an excellent text book, should be marked by so many imperfections. It should be easy to remedy these in a future edition.

THE PROCESS OF DENTITION AND ITS EFFECT ON OCCLUSION. By Hellman (Milo)—*Dental Cosmos*, Dec. 1923. Repr. 8°, 16 pp..

From the evidence produced the author deduces the following conclusions:

"The process of dentition is a physiologic manifestation, and as such it has to be established on a basis of variation.

The variation of the process of dentition is primarily associated with differences constantly manifested in the upper and lower jaws, in the different sexes, in different groups of the same sex and also in different races.

Differences in the eruption and shedding of teeth must be distinguished on the basis of a norm established on the evidence of dentitions in normal occlusion.

By having such a norm, a guide is obtained for deciding accelerations and retardations, "premature" or "too long retention" of deciduous teeth and "tardy" eruption of permanent ones.

In the digression from the normal in the process of dentition, differences in age, differences in length of period and differences in order of succession in the eruption and shedding of teeth must be distingiushed.

These differences are intimately related with the nature of overbite of the incisors, with differences in the frequency of malocclusion and with the "class" of malocclusion.

Differences in overbite are associated with accelerations in the shedding of the deciduous and in the eruption of the permanent incisors. The excessive overbite may be exaggerated by the retardation in the premolar-molar series.

A higher percentage of malocclusal manifestation is associated with the differences noted [above], by the increase in the length of the period and also by the modification in the order of succession with which the teeth are lost or erupted."

That the combination of all these factors also affects the percentage of Class II malocclusal manifestations.

ABNORMALITIES OF THE TEETH AND JAWS FROM THE STANDPOINT OF INHERITANCE. By Guyer (M. F.)—*Int. J. Orthodontia*, 1924, X, No. 6, 323–332.

An address read before the Alumni Society of the Dewey School of Orthodontia, April 12–13, 1923, Chicago, Ill.

The article brings no original contribution to the subject, but in a general discussion points out the uncertainties in the field, with the opinions of various authors. The conclusion is summarized in one sentence: "The presumption . . . is strongly in favor of there being an inheritable basis for many of the disharmonies and malformations encountered by the orthodontist, although unquestionably such plastic and active parts as the jaws are liable to pronounced modifications by extrinsic factors."

ON NEW METHODS OF DIAGNOSING DENTOFACIAL DEFORMITIES. By Lischer (B. E.)—*Int. J. Orthodont., Oral Surgery & Radiography*, 1924, X, No. 9, 521–541.

"Twenty-five years of clinical observation and practice have convinced the writer that malocclusion of the teeth occurs as a primary lesion in only a very limited number of cases, that malrelation of the dental arches without involvement of the supporting osseous structures is rare, and that many deviations heretofore classified as distoclusions and mesioclusions actually present deformity of the jaws." To facilitate study of these cases the author has evolved an ingenious method combining photography and tracings from the photographs, on semitransparent paper bearing millimeter and centimeter vertical and horizontal lines. He has further developed a simple apparatus by which it is possible to obtain on the living the angles of the lower jaw.

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